503

Automatic Data Processing Program for Marine Synoptic Radio Weather Reports

By James H. Johnson, Glenn A. Flittner, and
Marvin W. Cline

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INTRODUCTION

As part of a study of the distribution of north Pacific albacore, the staff of the Bureau of Commercial Fisheries Biological Laboratory, Honolulu, published monthly sea surface temperature charts of the eastern Pacific Ocean from 1957 through 1959. At the end of this phase of the north Pacific albacore investigations, the task of preparing and distributing the monthly charts was assumed by the staff of the Tuna Forecasting Program, Bureau of Commercial Fisheries Biological Laboratory, San Diego, Calif.

The purpose of the sea temperature charts now is to provide current sea temperature information to the tuna fishing industry, marine scientists, and meteorologists. That the charts are providing useful data to these groups is evident from the work of Broadhead and Barrett (1964), Dickson (1964), Flittner (1963), Magill (1963), Namias (1959, 1963), Quast (1964), and others.

Charts prepared at the BCF Biological Laboratory at San Diego are circulated in two series. Monthly sea temperature charts are published in the Bureau of Commercial Fisheries California Fishery Market News Monthly Summary, Part II - Fishing Information. A 15-day temperature chart for use by albacore fishermen is published from April through October as a supplement to the above publication for a limited area of the temperate eastern Pacific. Monthly summaries and charts of meteorological variables and heat budget computations are circulated to a limited mailing list under the title "Summary of Marine Synoptic Weather Reports."

The purposes of this paper are to describe an automatic data processing program (ADP) for summarization of synoptic marine weather reports, to describe the sea temperature reporting program, and to provide information on procedures for calculating the energy exchange at the air-sea interface for the Pacific Ocean.

Note.--James H. Johnson, Oceanographer; Glenn A. Flittner, Fishery Biologist (Research); and Marvin W. Cline, Mathematics Technician, Bureau of Commercial Fisheries Biological Laboratory, San Diego, Calif.

SOURCES OF DATA

The first International Maritime Conference, called in Brussels, Belgium, in 1853, conceived the idea that cooperating governments should encourage routine weather observations on ships, and that nations should prepare and publish charts of ocean currents, prevailing winds, average sea and air temperatures, and storm tracks based on these and other data. Since inception of the program, weather reporting has played an increasingly vital role in the safe and efficient operation of ships at sea.

Data used in preparing the charts and summaries come from a variety of sources. The main source is the synoptic marine radio weather report from ships at sea. Additional data are provided by organizations that mail coastal and ocean temperatures to the San Diego laboratory for inclusion in the charts. Early in the sea temperature reporting program, it became apparent that use of ADP would be helpful in preliminary data screening for radio transmission errors, for coding errors, and for compiling an average of about 10,000-15,000 synoptic marine weather observations each month. After the feasibility of summarizing sea temperature data by ADP methods was established, it was expedient to broaden the program to compile other meteorological variables for use by scientists in marine climatology and other research studies. The elements for computation of the energy exchange at the air-sea interface were available from these summaries and monthly averages of this exchange by 5-degree quadrangles are now computed routinely.

The basic data utilized by the system described below is the "International Surface Report from Ship in Full Form, FM 21.A," approved by the World Meteorological Organization (WMO). Cooperating American and foreign-flag vessels make, record, and transmit the standard marine weather observations according to established procedures set up by WMO. Observations taken at 0000, 0600, 1200, and 1800 Greenwich Mean Time daily are transmitted to designated commercial and Government radio stations around the world (see U.S. Navy Hydrographic Office Publication No. 206, Radio Weather Aids, 1958).

Depending on geographical location, ships at sea report marine weather to designated receiving stations. North Pacific Ocean data for the region west of the 180th meridian are received by "Observer Tokyo." Data for the region east of the 180th meridian are received by "Observer San Francisco" and are relayed to the U.S. Weather Bureau Forecast Center at San Francisco International Airport, San Bruno, Calif. This center transmits both Observer San Francisco and Tokyo reports to other agencies via teletype circuits. The BCF Biological Laboratory, San Diego, maintains a drop on Service "O", Circuit 8274 to receive ship surface weather information 24 hours daily.

The ship weather report code adheres to the following symbolic 5-digit word group format:

$YQL_aL_aL_a$ $L_oL_oL_oGG$ $Nddff$ $VVwwW$

$PPPTT$ $N_hC_LhC_MC_H$ D_sv_sapp

$OT_sT_sT_dT_d$ $1d_wd_wP_wH_w$ ICE c_2KD_ire

Additional groups are coded when required; supplementary information following the ICE word group is usually transmitted in plain language. Definitions of symbols are given in table 1.

Since a large percentage of the incoming marine weather observations emanates from vessels having observers with limited meteorological experience, the question arises as to the validity of certain portions of the standard weather message. It is recognized that certain observational errors may be introduced by equipment in poor condition or through faulty operation. The problem of variability of ship's injection system thermometer readings, as an example, has been reviewed by Saur (1963). From his studies aboard U.S. Navy radar picket vessels, Military Sea Transport Service ships, and oil tankers, Saur found that the average injection temperature bias from that of a bucket temperature taken at the surface was about + 1.2° F. In addition to instrument error, one complicating factor is that sea temperatures are not reported directly but, rather must be derived from air temperatures and air-sea temperature differences. In the near future the Commission on Maritime Meteorology of the WMO plans to discuss the possibility of changing the marine weather coding instructions so that sea temperature will be reported directly. Another complicating factor is the problem of communication errors. A study by Gibson (1962) for the Atlantic Ocean showed that 19 percent of the sea temperatures received on 1 day were incorrect; these errors were due to improper coding procedures, to communication transmission errors, and to faulty instruments.

Table 1.--Elements of the ship's surface synoptic code, FM 21.A[1]

Symbols	Definitions of symbols
Y	Day of week
Q	Octant of globe
$L_aL_aL_a$	Latitude in degrees and tenths
$L_oL_oL_o$	Longitude in degrees and tenths
GG	Greenwich civil time of observations, to nearest hour
N	Fraction of celestial dome covered by clouds
dd	Direction from which the wind is blowing (tens of degrees)
ff	Wind speed in knots
VV	Visibility (in code)
ww	Present weather (in code)
W	Past weather (in code)
PPP	Sea-level pressure (tens, units, tenths) millibars (mb).
TT	Temperature of the air (whole degrees Centigrade)
N_h	Fraction of celestial dome covered C_L or C_M cloud
C_L	Clouds of types stratocumulus, stratus, cumulus, cumulonimbus (in code)
h	Height of base of lowest C_L or C_M cloud above sea
C_M	Clouds of types altocumulus, altostratus, nimbostratus (in code)
C_H	Clouds of types cirrus, cirrostratus, cirrocumulus (in code)
D_s	Ship's course (in code)
v_s	Speed of ship in knots (in code)
a	Characteristic of barometric tendency (in code)
pp	Amount of barometric change (units and tenths) millibars (mb.)
O	Group designator
T_sT_s	Difference between air and sea temperature (half degrees Centigrade)
T_dT_d	Temperature of dew point (whole degrees Centigrade)
1	Group designator
d_wd_w	Direction from which waves are coming (tens of degrees)
P_w	Period of waves (in code)
H_w	Mean height of waves (in code)
ICE	Group designator for ice group
c_2	Description of kind of ice (in code)
K	Effect of ice on navigation (in code)
D_i	Bearing of ice limit (in code)
r	Distance of ice from ship (in code)
e	Orientation of ice field (in code)

[1] Adapted from U.S. Weather Bureau Manual of Marine Meteorological Observations, Circular M (11th ed.), January 1963, p. 8.

Errors introduced into the weather message for various reasons are often difficult to note unless they are of serious nature. Data screening at the BCF Biological Laboratory in San Diego is designed primarily to detect the following errors:

1. Departures from major 5-digit groupings: e.g., teletype garbles, run-on groups of 5 or more digits not separated by a space, failure to shift from lower to upper case, and vice versa.

2. Major coding errors in barometric pressure readings: all coded messages are interpreted for values between 950.1 and 1049.9 mb.; coded values greater than 500 are assigned to the range 950.1-999.9 mb., and values less than 500 are assigned to the range 1000.0-1049.9 mb. Observed barometric pressures will be refined further in the future when monthly barometric averages and associated statistics become available for screening purposes.

3. Major errors in sea temperatures: sea temperature observations are screened by comparison with a table of values interpolated from monthly means for the north Pacific Ocean found in the "Atlas of Climatic Charts of the Oceans," U.S. Weather Bureau. Temperatures outside a selected range are rejected and placed in a summary listing for inspection by the analyst.

DISTRIBUTION OF OBSERVATIONS

Because the data used are compiled primarily from merchant marine weather reports, the distribution of observations over the ocean is irregular. Observations are most numerous in the major shipping lanes from San Francisco to Hawaii, San Francisco to Japan, Panama to San Diego, Los Angeles and San Francisco, and from Seattle to Japan. Shipping lanes of secondary importance are from San Diego to Hawaii, Panama to Hawaii, and Panama south to the ports off the west coast of South America. Vast regions of the equatorial zone and south Pacific Ocean have much less merchant vessel traffic than the north Pacific and, consequently, fewer reports are received from these areas. Sample distributions of the number of usable sea temperature observations are given in figures 1 and 2.

In recent years, progress has been made in obtaining coverage from some regions that heretofore have yielded few reports. One quite important region that has been little covered is the area off the west coast of South America. The importance of this area can be appreciated by examining the world fishing statistics. In 1961, FAO reported that Peru was surpassed only by Japan in world production of fish and fish byproducts. Recently, WMO has asked that cooperating ships steaming in the area south of the equator and from the west coast of South America to long. 140° W. send reports to "Observer San Francisco." Furthermore, the U.S. Weather Bureau has recently established a Port Visitation Office in Panama and is encouraging vessels passing through the canal into the Pacific to send reports to designated receiving agencies.

AUTOMATIC DATA PROCESSING OF WEATHER REPORTS

The Program

Incoming data are received from the U.S. Weather Bureau, San Francisco International Airport, San Bruno, Calif., via the landline teletype circuit, Service "O", Circuit 8274, mentioned previously. Each transmission is converted to a 5-channel paper tape by a teletype reperforator receiver. Concurrent with the reperforator operation, the transmission is duplicated on a page printer machine for message verification purposes and as a backup when the reperforator malfunctions.

The perforated tape is fed into an IBM 047 tape-to-card key punch machine to convert each ship's weather observation to standard data card format. These data cards are then accumulated each month for processing. The data are presorted by octant and longitude into 10-degree wide strips to facilitate processing by the machine and to provide a logical output format. The information on each of the sorted cards is then loaded onto magnetic tape for high-speed input to the computer. The basic steps are schematized in figure 3.

The program in current use is written in FORTRAN-62 source language for the Control Data Corporation 1604 computer located at the University of California, San Diego. A machine language deck has been prepared from the source language statements for routine processing of synoptic data. The computer program processes the cards and prepares output summaries for each 10-degree strip of longitude separately until all accumulated cards are processed. Data cards are summarized at the rate of 5 per second and the output tape is produced at the rate of 40 lines per second. The output tape is subsequently listed on multicopy paper for tabulation assembly. The flow charts in figures 4-6 depict the major data processing functions performed; numerical designators are keyed to processing statements within the program listing in Appendix A.

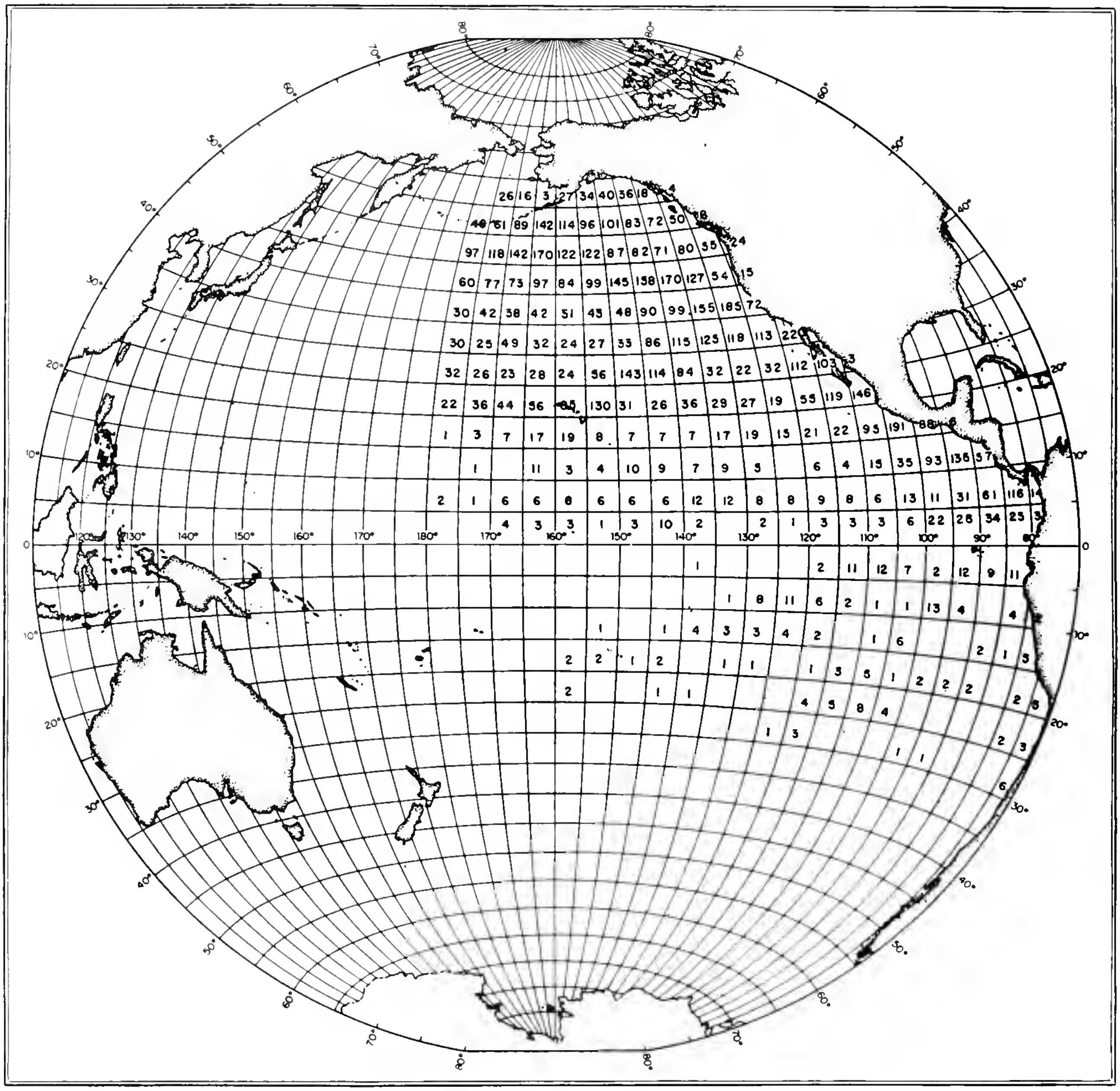

Figure 1.--Distribution of screened sea temperature observations derived from the synoptic marine weather observations, August 1963.

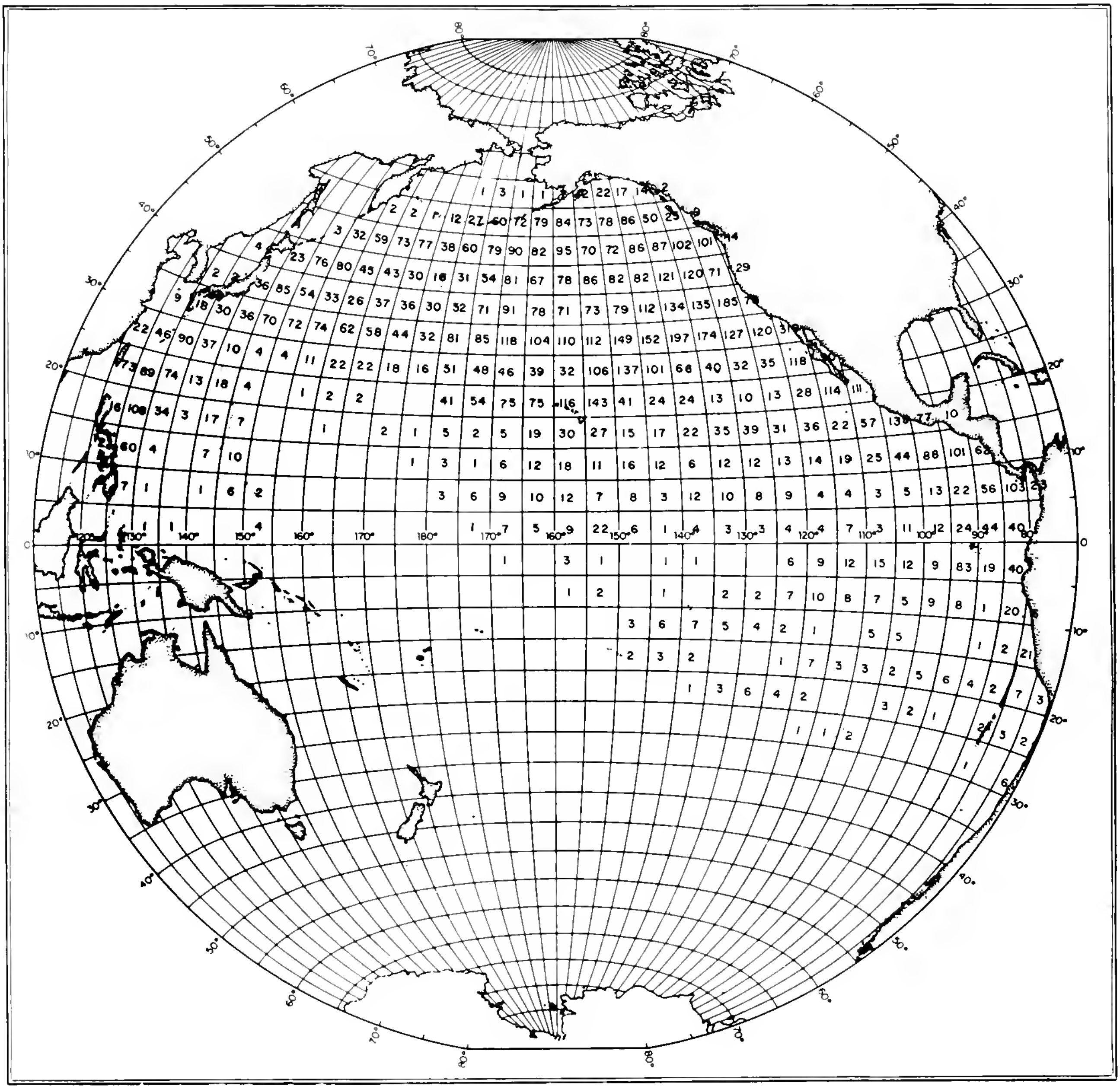

Figure 2.--Distribution of screened sea temperature observations derived from the synoptic marine weather observations, February 1964.

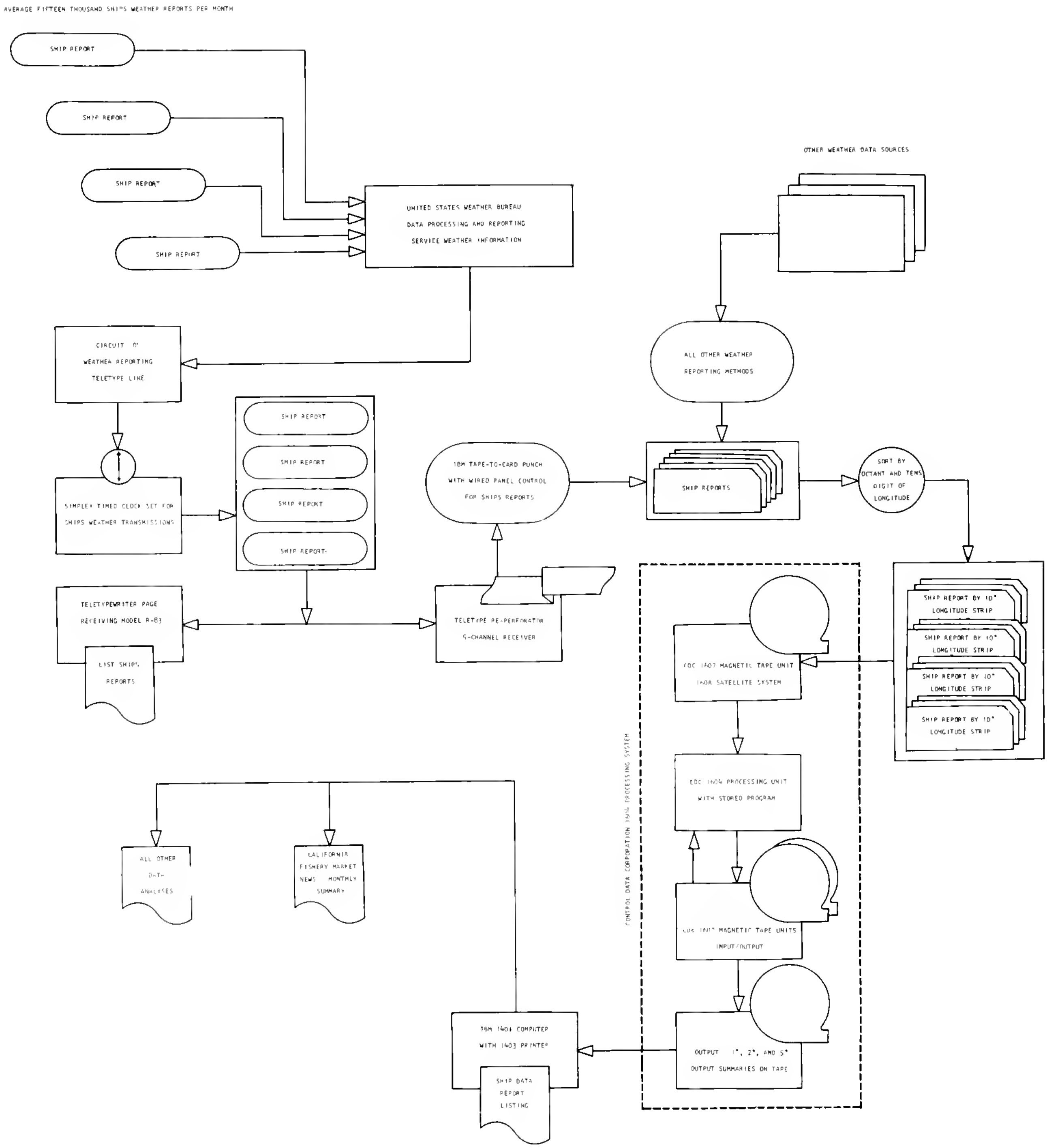

Figure 3.--Schematic diagram of the automatic weather data processing system in use by the Bureau of Commercial Fisheries Biological Laboratory, San Diego, Calif.

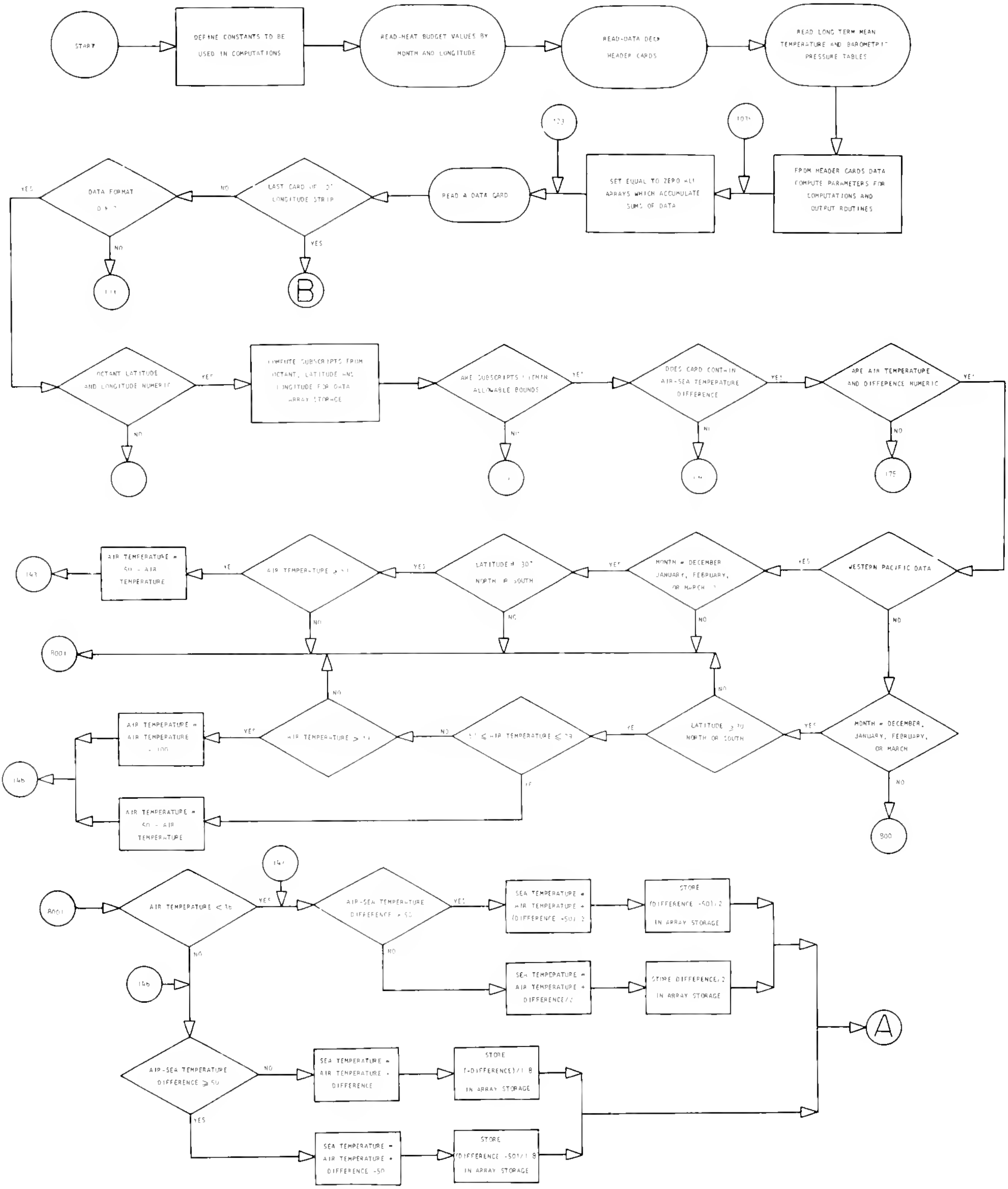

Figure 4.--Schematic flow chart depicting the major data processing functions performed by the Control Data Corporation 1604 computer at the University of California, San Diego. See Appendix A for key to numerical designations.

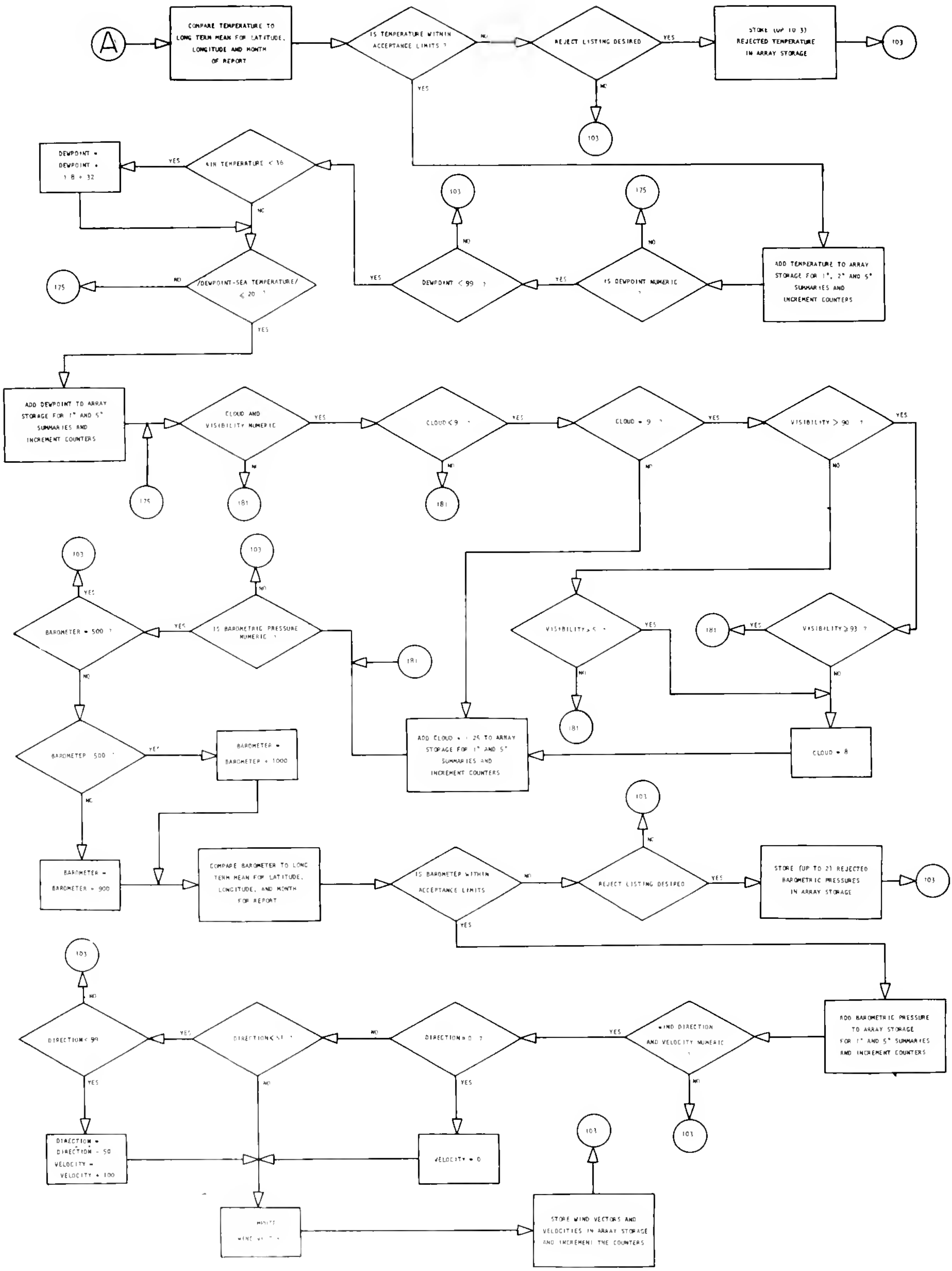

Figure 5.--Schematic flow chart depicting the major data processing functions performed by the Control Data Corporation 1604 computer at the University of California, San Diego. See Appendix A for key to numerical designations. (Continued)

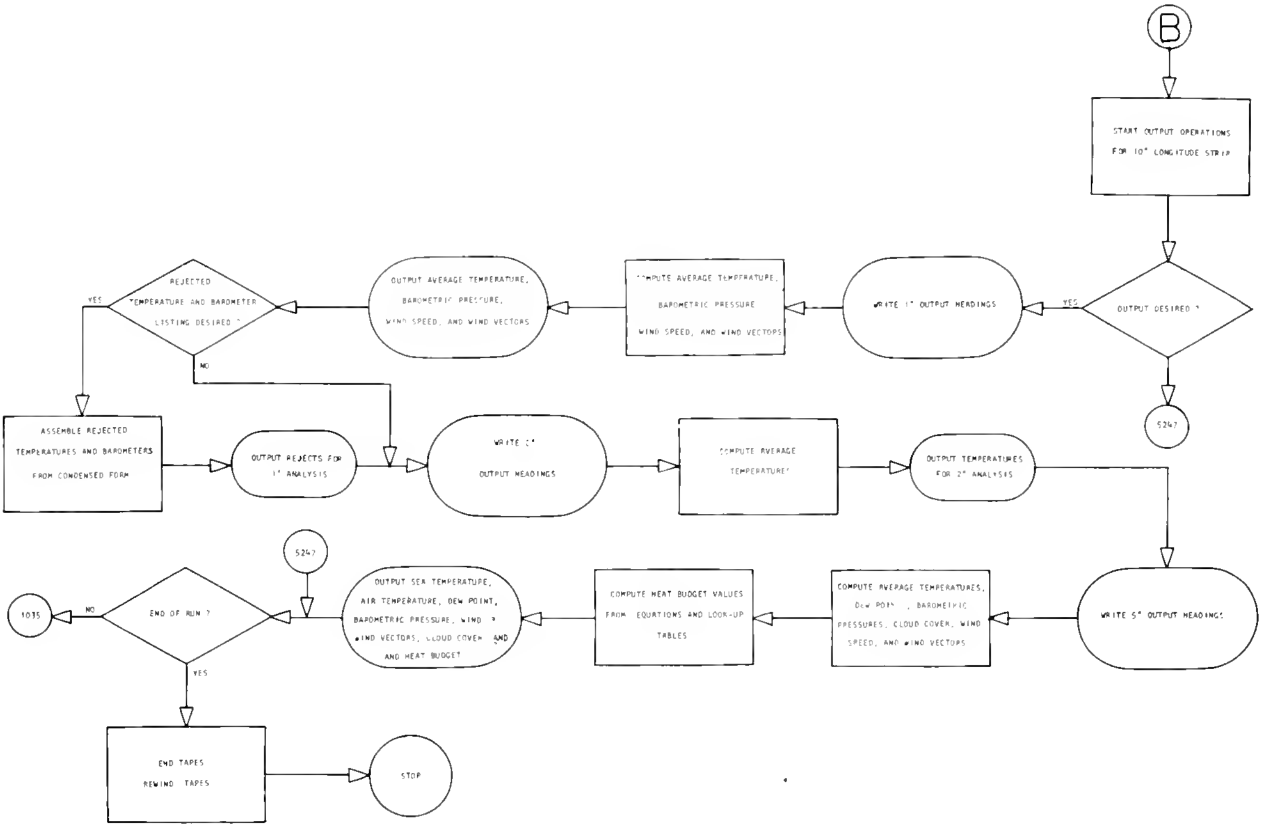

Figure 6.--Schematic flow chart depicting the major data processing functions performed by the Control Data Corporation 1604 computer at the University of California, San Diego. See Appendix A for key to numerical designations. (Continued)

Monthly Data Readout

It is becoming increasingly clear to marine scientists that much interaction occurs between the ocean and the atmosphere (Eber and Sette, 1959; Hanzawa, 1962; Namias, 1963; Uda, 1960, 1962). To provide data for research into air-sea interaction studies, not only sea surface temperatures but also other variables contained in the marine synoptic weather report are summarized. The basic elements of the monthly data compilations are listed in four major tables, as follows[1]:

Table 1.001-1.069--Sea surface temperatures (° F.) with number of observations by 1-degree quadrangles for the month of [entry changes each month].

Table 2.001-2.184--Barometric pressures (mb.), X- and Y-wind vectors (knots), and average wind speed (knots) with number of observations by 1-degree quadrangles for the month of [same as above].

Table 3.001-3.046--Sea surface temperatures (° F. and C.) and number of observations by 2-degree quadrangles for the month of [same as above].

Table 4.001-4.069--Sea surface temperatures (° C.), air temperatures (° C.), dew point temperatures (° C.), barometric pressures (mb.), X- and Y-wind vectors (knots), average wind speeds (knots), cloud cover (tenths of sky covered), and heat budget (calories per square centimeter per day), with number of observations by 5-degree quadrangles for the month of [same as above].

Sample page copy of each table listed above is included in Appendix C. Each table conforms to the following conventions:

1. Latitude and longitude range headings--Identify a 10-degree wide strip of longitude and give its length in latitude. Each successive page with identical range headings belongs in the same 10-degree strip.

2. Latitude and longitude indices--Give map location of each piece of data. Answer is

[1]For convenience in output assembly, pages within each table are numbered consecutively from .001.

assumed to be for the geometric center of each quadrangle. Location given on output is actually the corner of the quadrangle and follows this convention:

Octants 0, 1 - lower right corner
Octants 2, 3 - lower left corner
Octants 5, 6 - upper right corner
Octants 7, 8 - upper left corner

(Where octant designations conform to Hydrographic Office Publication No. 206 code form FM 21.A. "Surface Report From Ship in Full Form.")

3. Wind vectors--Wind vectors follow this convention:

(a) X--vectors run due east and west
East--positive
West--negative

(b) Y--vectors run due north and south
North--positive
South--negative

4. Average wind speed--The simple average of all observations irrespective of direction (Note - does not necessarily equal $\sqrt{X^2 + Y^2}$).

5. Heat budget computations--The net energy exchange at the air-sea interface. The printout has the following sign convention:
(a) Energy into sea--positive
(b) Energy out of sea--negative

The computer printout labels of various components of the equation are:

Q(T) - total (net) energy exchange across air-sea interface)
Q(I) - incoming solar radiation corrected for cloud cover
Q(R) - radiation reflected by sea surface
Q(B) - back radiation
Q(E) - heat loss or gain through evaporation or condensation
Q(H) - sensible heat conduction between sea and air

Energy exchange equations will be discussed in subsequent sections of this paper.

The following notes are given to clarify some aspects of the data:

1. A blank in heat budget output [Q(T), Q(I), Q(R), Q(B), Q(E), Q(H)] is equal to 0.

2. When any heat budget value [Q(T), Q(I), Q(R), Q(B), Q(E), Q(H)] is between -1 and 0, a minus sign only appears as entry.

3. Any entry or a blank followed by (0) means no data for that quadrangle.

CHARTS DERIVED FROM MONTHLY READOUT

Sea Surface Temperature Charts

Examples of monthly sea surface temperature charts obtained by using the data summaries and reported in the Bureau of Commercial Fisheries California Fishery Market News Monthly Summary, Part II - Fishing Information are shown in figures 7-12. Figure 7 depicts the monthly sea surface isotherm configuration derived from ships' weather reports, average sea temperatures at Weather Ship Stations November and Papa, and average temperatures of coastal stations. Because coastal station data are mailed and must reach the BCF San Diego Laboratory by the first day after the close of a month for processing, the coastal station averages, except for that reported at the pier of Scripps Institution of Oceanography, usually represent only about the first 25 days of each month. Coastal stations included in figure 7 are as follows:

Station	Location: Latitude	Location: Longitude
Langara Island	54°15' N.	133°03' W.
Cape St. James	51°56' N.	131°01' W.
Quatsino Island	50°27' N.	128°02' W.
Amphitrite Point	48°55' N.	125°32' W.
Umatilla Lightship	48°10' N.	124°50' W.
Columbia River Lightship	46°11' N.	124°11' W.
Blunt's Reef Lightship	40°26' N.	124°30' W.
Russian Gulch State Park	39°18' N.	123°48' W.
Sonoma Coast State Park	38°23' N.	123°05' W.
Farallon Island Lightship	37°46' N.	122°42' W.
Hopkins Marine Station	36°38' N.	121°55' W.
Gaviota State Park	34°28' N.	120°14' W.
Santa Barbara	34°24' N.	119°42' W.
Doheny State Park	33°28' N.	117°41' W.
Scripps Institution of Oceanography	32°52' N.	117°15' W.
Ensenada	31°52' N.	116°38' W.
Guadalupe Island	28°41' N.	118°17' W.
Cedros Island	28°15' N.	115°10' W.

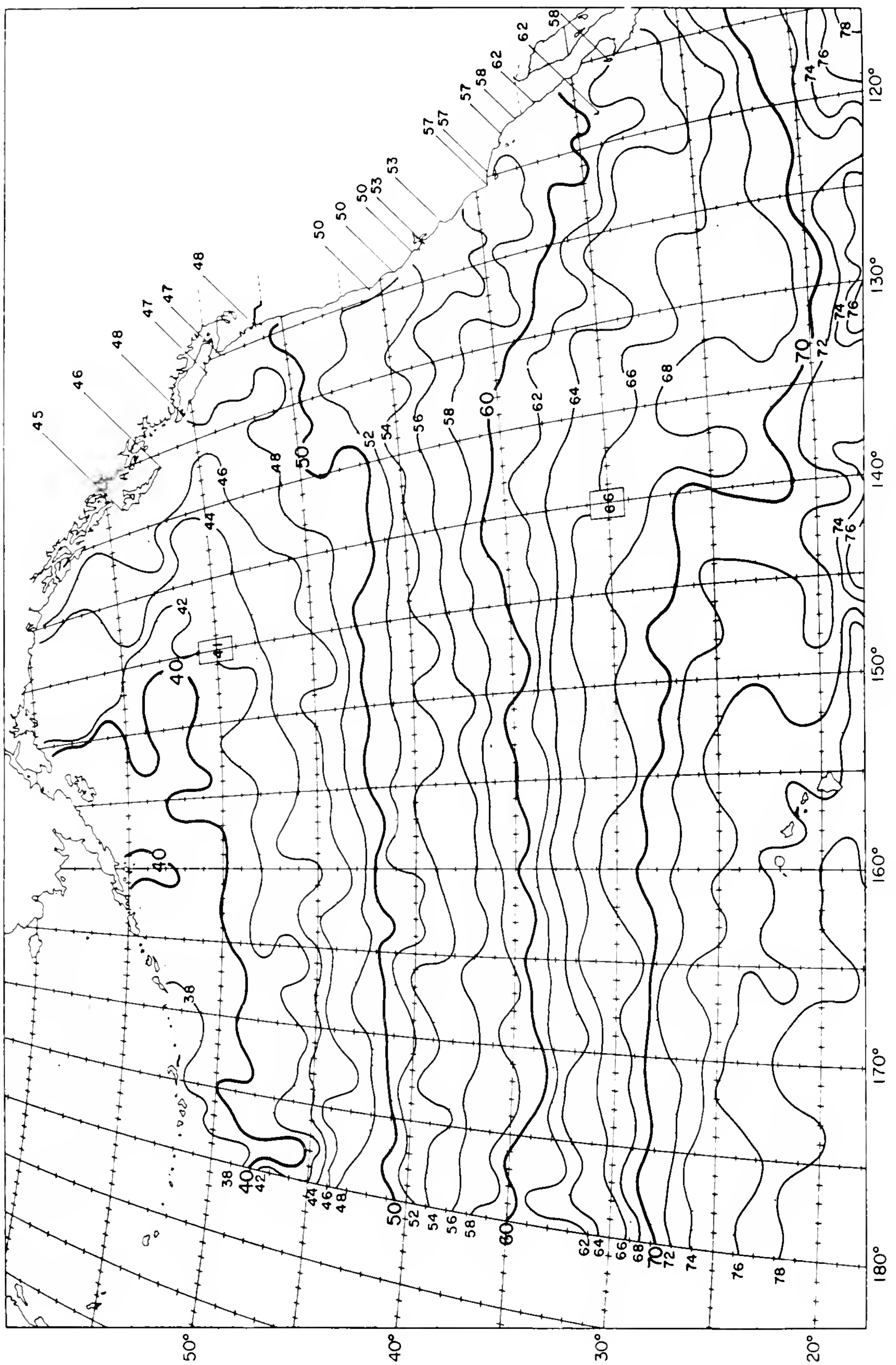

Figure 7.--Mean sea surface temperatures (° F.), February 1-29, 1964.

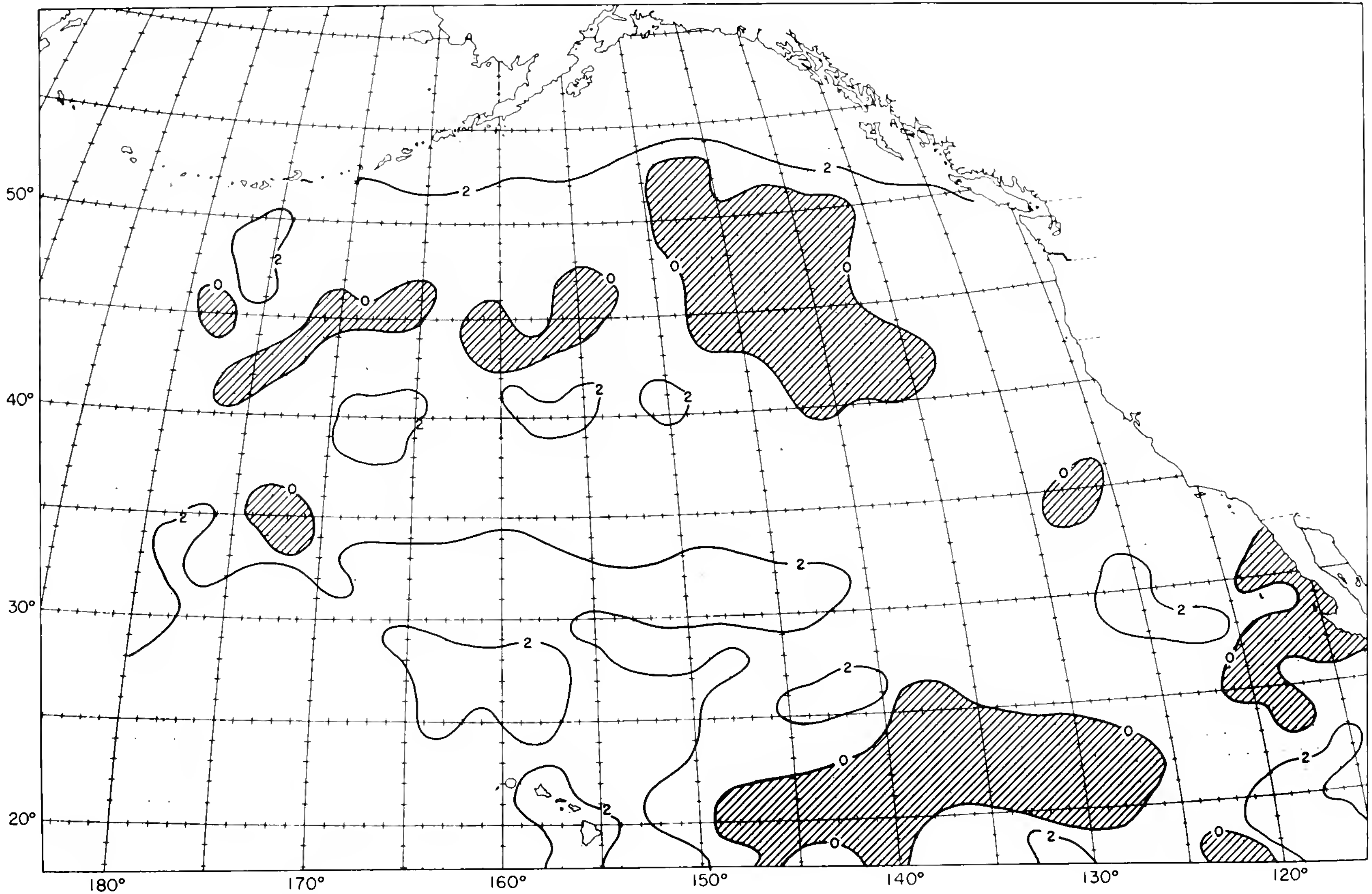

Figure 8.--Deviation of sea surface temperatures (° F.) from long-term mean, February 1964. Hatched areas colder in 1964.

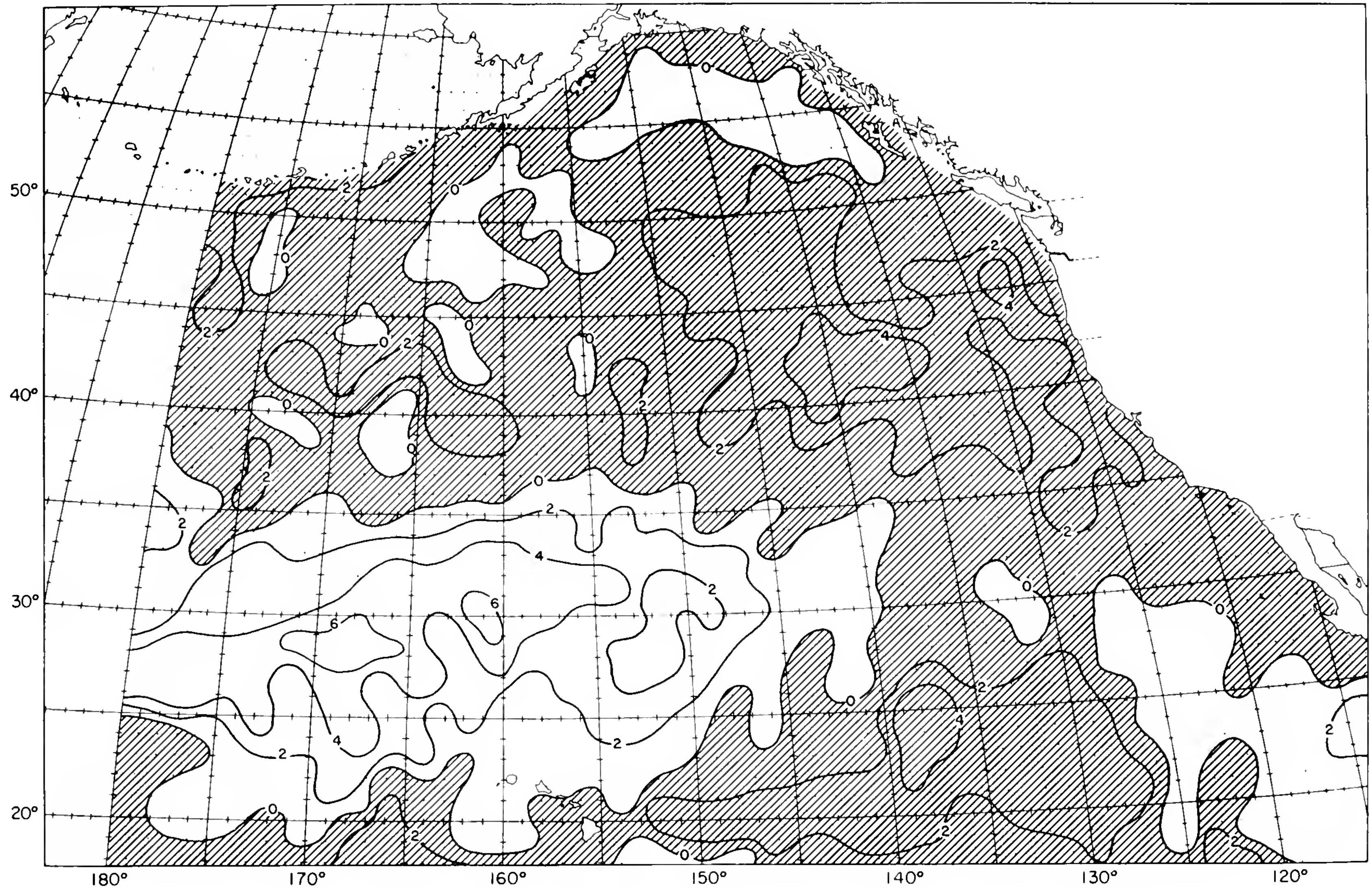

Figure 9.--Deviation of sea surface temperatures (^{O} F.) from February 1963 - February 1964. Hatched areas colder in 1964.

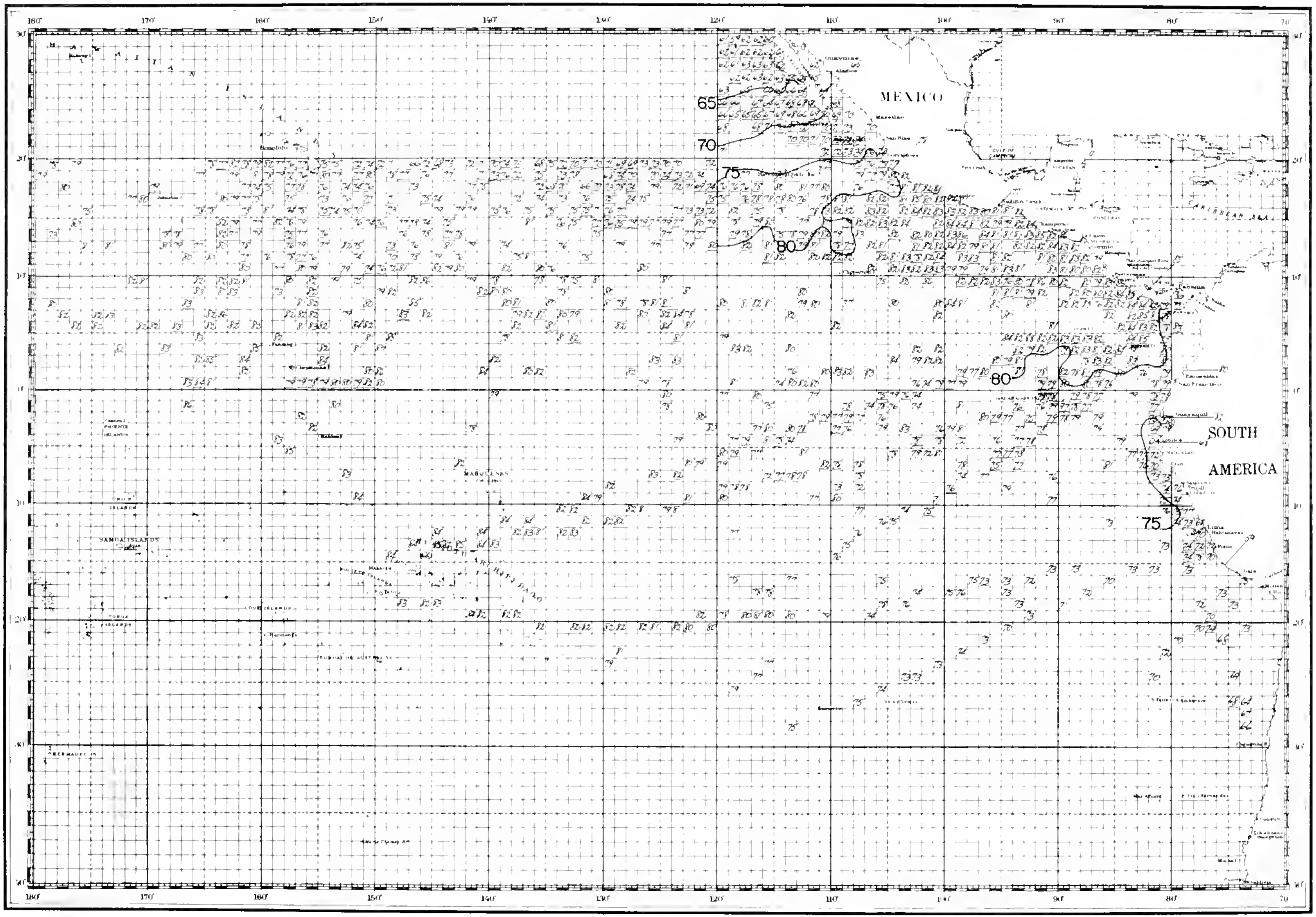

Figure 10.--Sea surface temperatures by 1-degree quadrangles, February 1-29, 1964. Temperatures underlined indicate average of two or more observations.

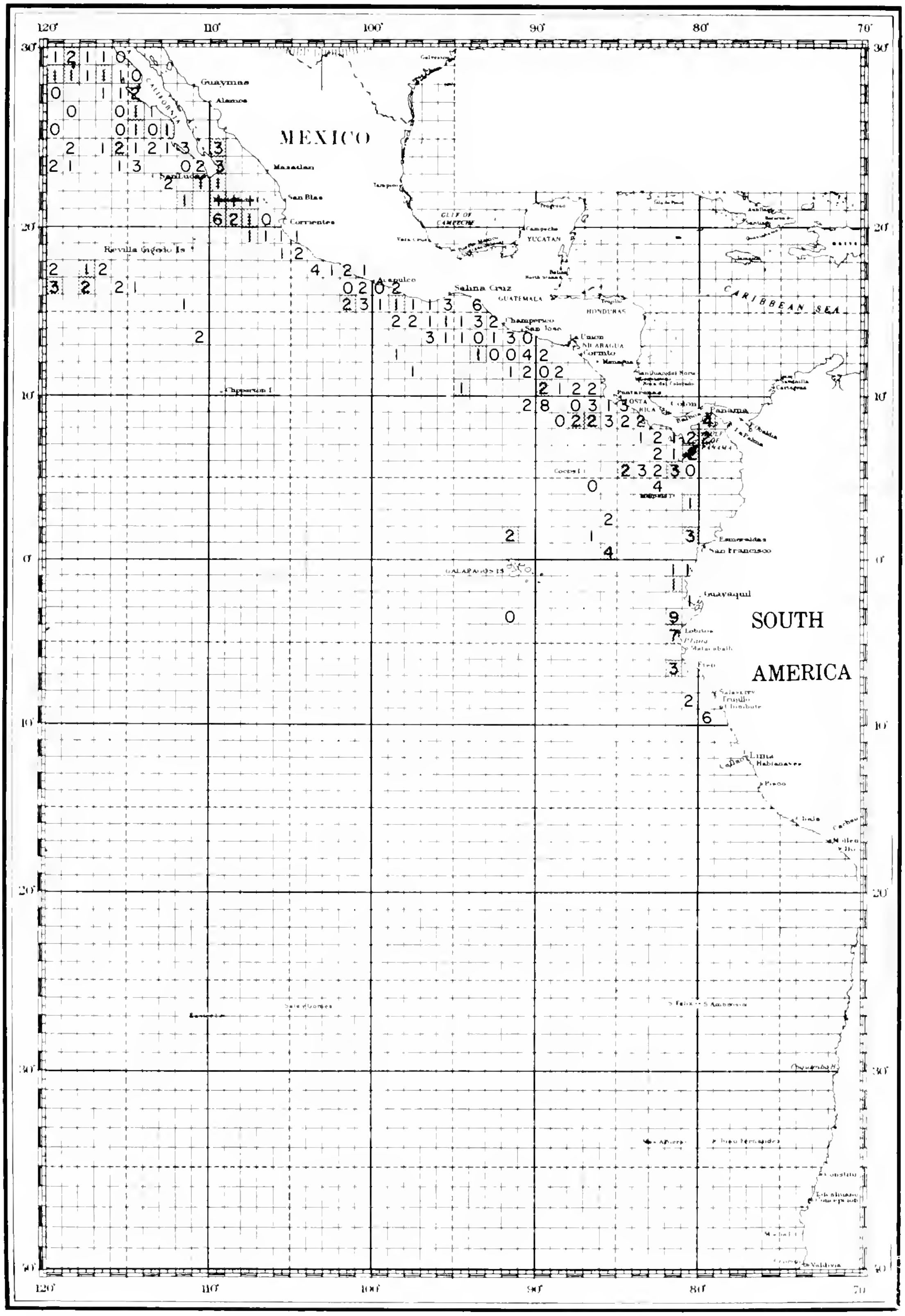

Figure 11.--Deviation of sea surface temperatures (° F.) from February 1963 - February 1964. Shaded areas colder in 1964.

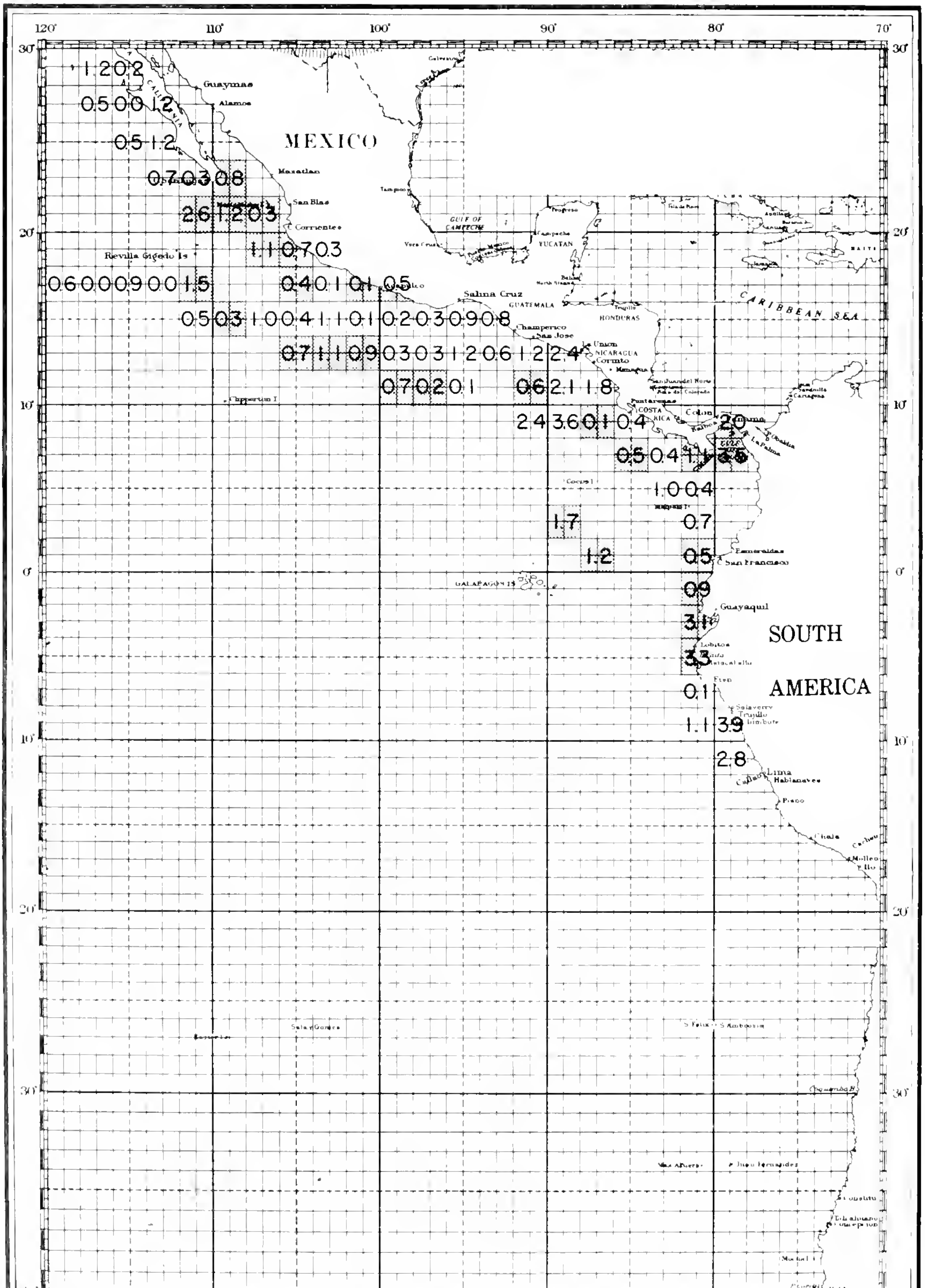

Figure 12.--Deviation of sea surface temperatures (° F.) from 12-year mean (1947-58) by 2-degree quadrangles, February 1964. Shaded areas colder in 1964.

Monthly sea surface temperature deviations for February 1964, from the long-term mean charts given in H.O. 225, World Atlas of Sea Surface Temperatures, 2d ed., 1944, appear in figure 8. The exact base period used for construction of the mean charts is not known.[2]

The deviation of sea surface temperature, February 1964, from the corresponding month of the previous year is given in figure 9.

Whereas three of the charts (figs. 7-9) encompass the temperate north Pacific Ocean east of the 180th meridian, the remainder (figs. 10-12) give data for the eastern tropical Pacific Ocean. The first (fig. 10) of these gives actual average temperatures by 1-degree quadrangles; underscored values represent averages from two or more observations. The next chart (fig. 11) gives the deviation from the previous year by 1-degree quadrangles, and the last (fig. 12) shows the deviation by 2-degree blocks from the 12-year (1947-58) mean prepared by Renner (1963). When the 10-year (1950-59) mean is completed by the BCF Biological Laboratory at Stanford, this chart, too, will be based on the same period. Because of the scarcity of observations from the tropical regions, actual values are presented instead of contoured values.

From April through October, as a supplement to the Bureau of Commercial Fisheries California Fishery Market News Monthly Summary, Part II - Fishing Information, a series of charts covering 15-day intervals is prepared and distributed to albacore fishermen and to others interested in receiving it (fig. 13). This chart covers the region from the coast of North America to long. 136°30' W. and from lat. 25° N. to 52° N. It is designed to span the area and season when the commercial albacore fishery takes place off the Pacific coast.

Meteorological Charts

Charts are prepared each month from the readout for averages of cloud cover (figs. 14 and 15), wind speed (figs. 16 and 17), air temperature (figs. 18 and 19), dew point temperature (figs. 20 and 21), sea temperature (figs. 22 and 23), and barometric pressure (figs. 24 and 25). Values are summarized by 5-degree quadrangles of latitude and longitude. Values are not plotted for 5-degree quadrangles having fewer than five observations. Two charts of each of the variables at opposite climatological seasons show the magnitude of seasonal changes occurring over the ocean. Charts for August 1963 cover the Pacific only from the American coasts to long. 180° because it was not until January 1964 that data were programmed to cover the entire Pacific Ocean. These data are distributed monthly on a limited mailing list.

Energy Exchange Computations and Charts

The marine synoptic weather report contains basic data for computation of the energy exchange occurring at the air-sea interface. The methods described below represent one of the first attempts to monitor the gross energy flux at the air-sea interface over a broad expanse of the ocean on a monthly basis.

For a given area and time period, the equation for the energy exchange at the air-sea interface is $\underline{Q_T} = \underline{Q_I} - \underline{Q_R} - \underline{Q_B} - \underline{Q_E} - \underline{Q_H}$. (See page 10 for definitions of elements of this equation.) The gain or loss of heat, added to that resulting from horizontal and vertical advection, represents the total heat energy available to the upper mixed layer of the ocean. Energy exchange calculations presented here do not take into account changes in heat brought about by advection.

Energy exchange equations have been reviewed in detail by Sverdrup, Johnson, and Fleming (1942), Jacobs (1951), Roden (1959), Laevastu (1960), and others. Opinion differs considerably as to the accuracy of the various equations describing the total energy exchange at the air-sea interface. It is not the intent here to review the accuracy of the many different equations that have been proposed. Controlled experiments similar to those carried out on Lake Hefner by Anderson (1954) and Marciano and Harbeck (1954) are needed to determine which of the equations most closely describes what actually takes place in the ocean.

$\underline{Q_I}$, incoming solar radiation corrected for cloud cover (in cal./cm.^{2}/day), is determined from the following equation proposed by Berliand (1960):

$$\underline{Q_I} = (\text{Berliand table})^3 \times (1 - aC - bC^2)$$

where $\underline{C}$ = cloudiness in tenths
$\underline{b}$ = 0.38
and $\underline{a}$ = a function of latitude as follows:

Latitude:	0	5	10	15	20	25
a	0.38	0.40	0.40	0.39	0.37	0.35
Latitude:	30	35	40	45	50	55
a	0.36	0.38	0.38	0.38	0.40	0.41

[2]The introduction of H.O. 225 states as follows: "This world atlas of sea surface temperatures was prepared by the Scripps Institution of Oceanography, La Jolla, California, from all sea surface temperature information collected by the U.S. Hydrographic Office, together with all available data from other sources, with special reference to regions of few observations. It is believed that this compilation represents the most accurate pattern of sea surface temperatures of the world yet prepared." The staff of the Bureau of Commercial Fisheries Biological Laboratory, Stanford, Calif., is now preparing a 10-year mean for the period 1950-59. When the new mean becomes available, the anomaly chart will be based on it.

[3]See Appendix table B-1 for Berliand's table which lists values of incoming solar radiation with a clear sky.

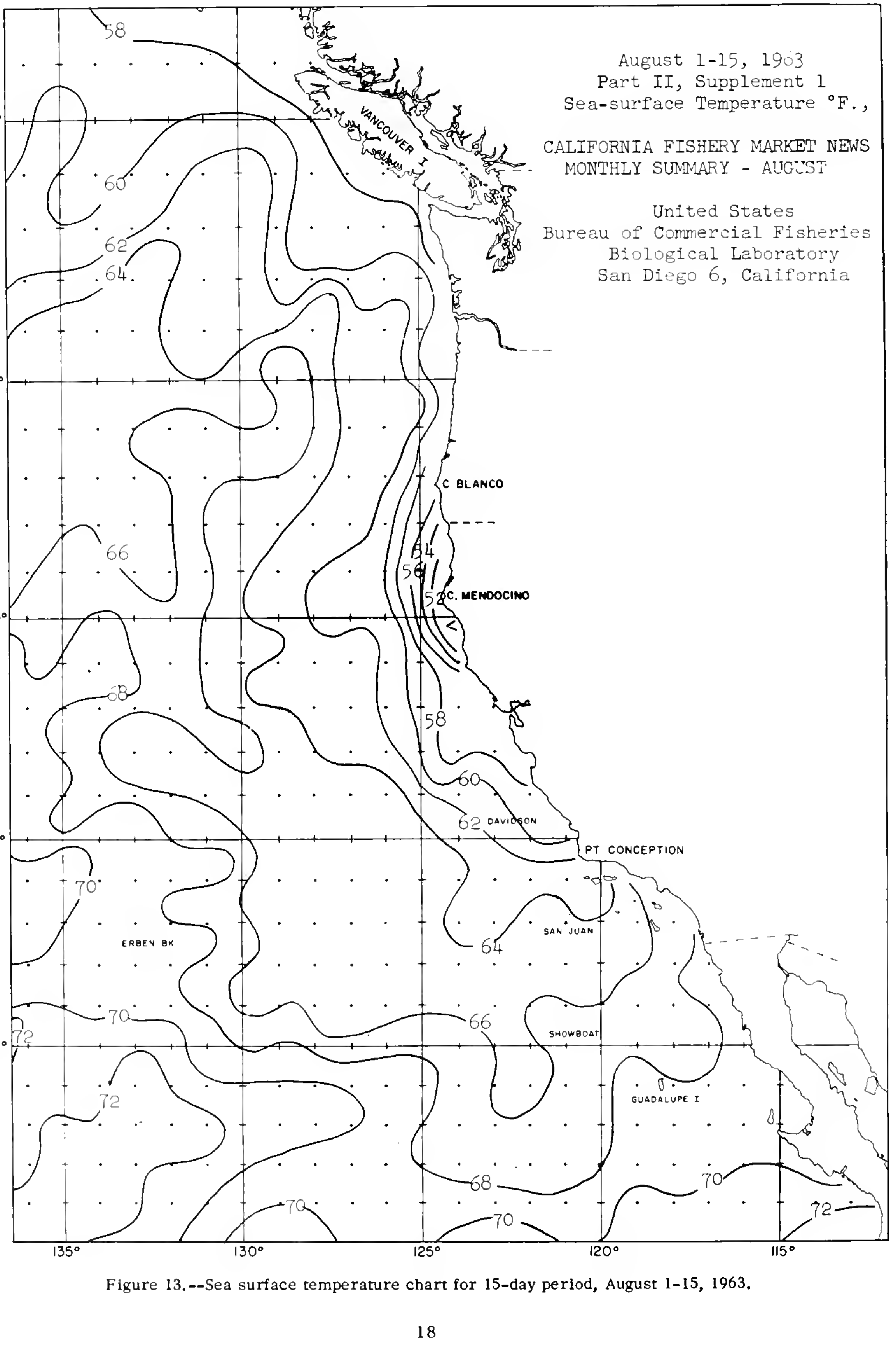

Figure 13.--Sea surface temperature chart for 15-day period, August 1-15, 1963.

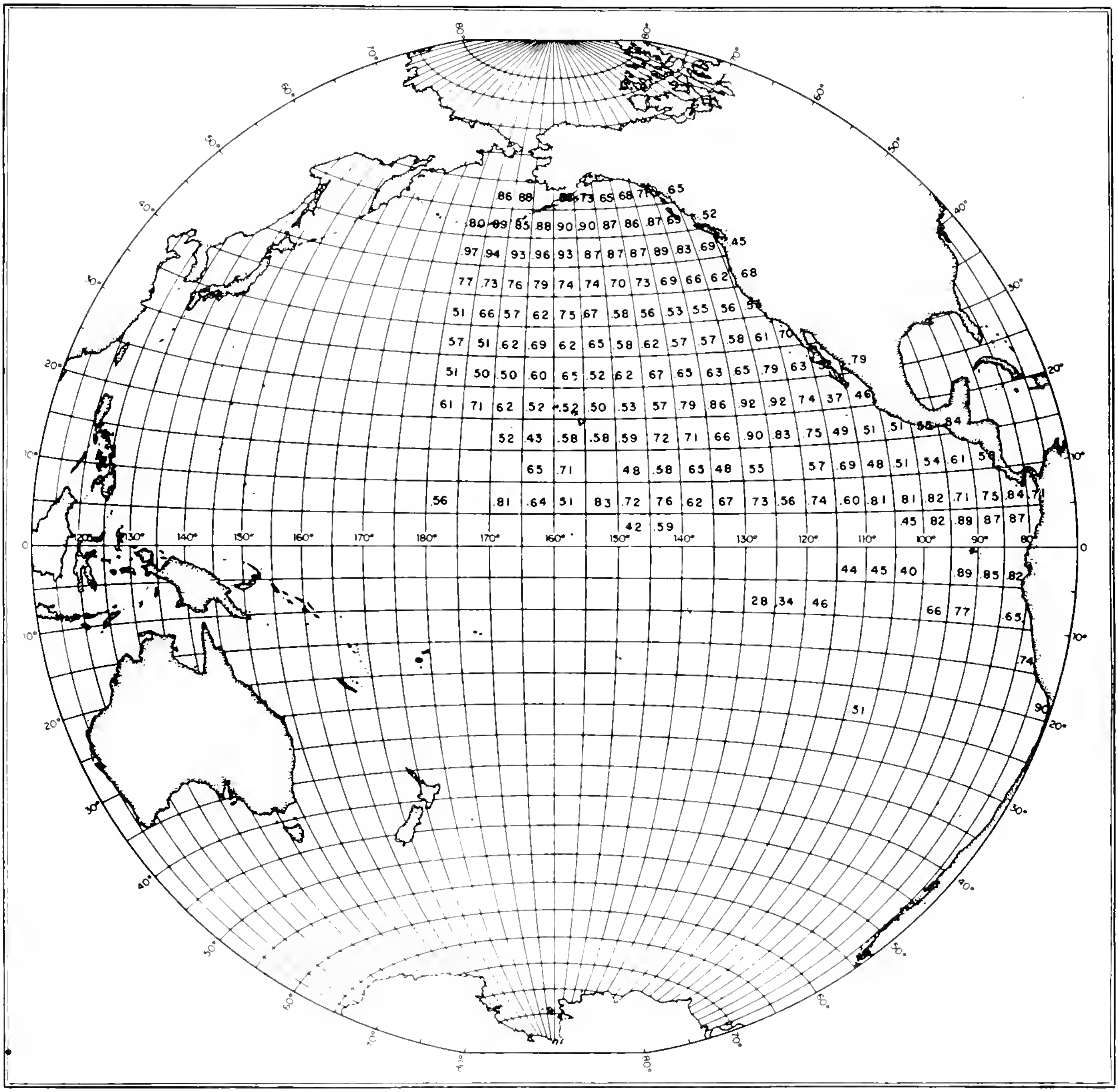

Figure 14.--Cloud cover (hundredths), August 1963.

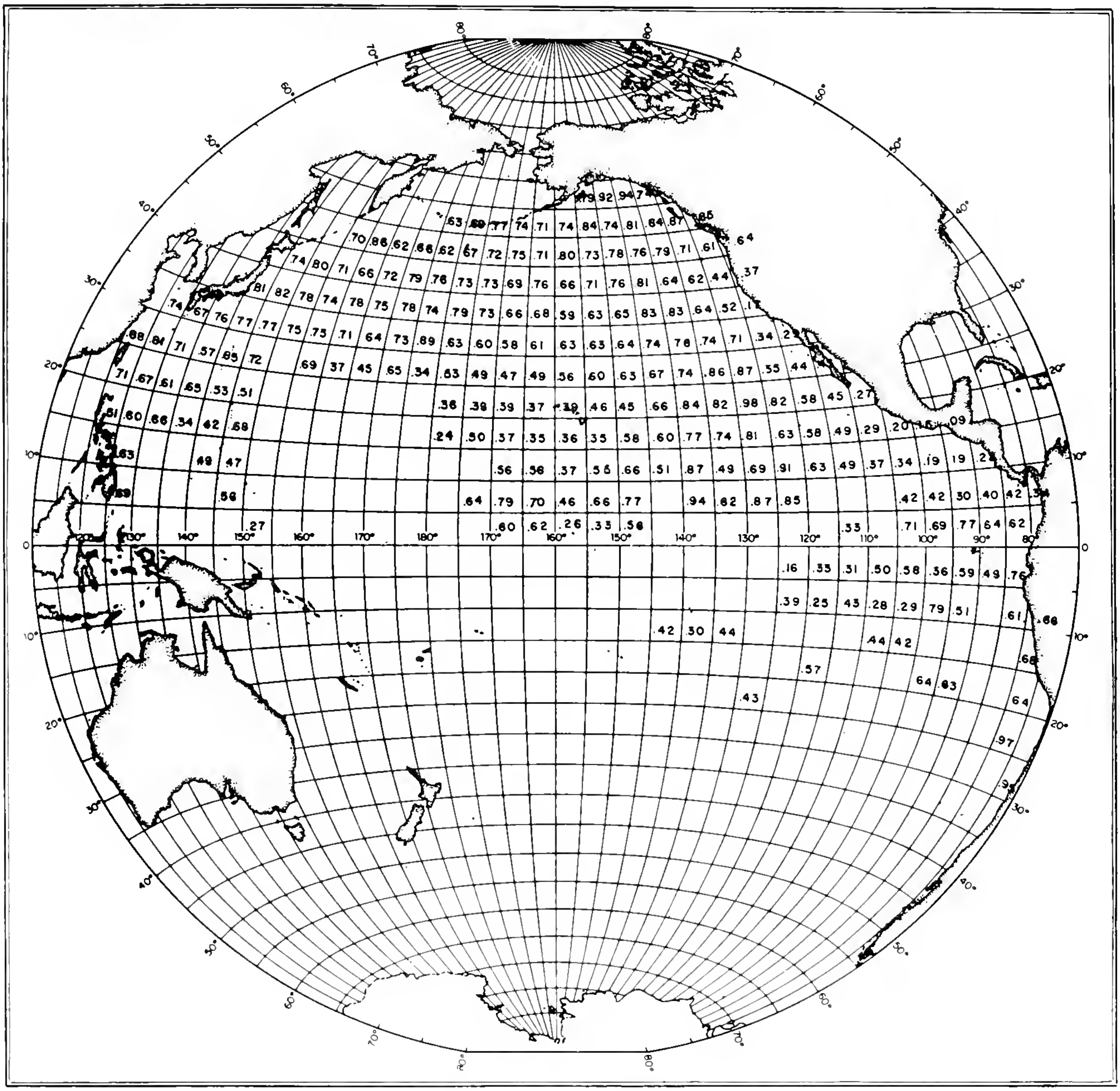

Figure 15.--Cloud cover (hundredths), February 1964.

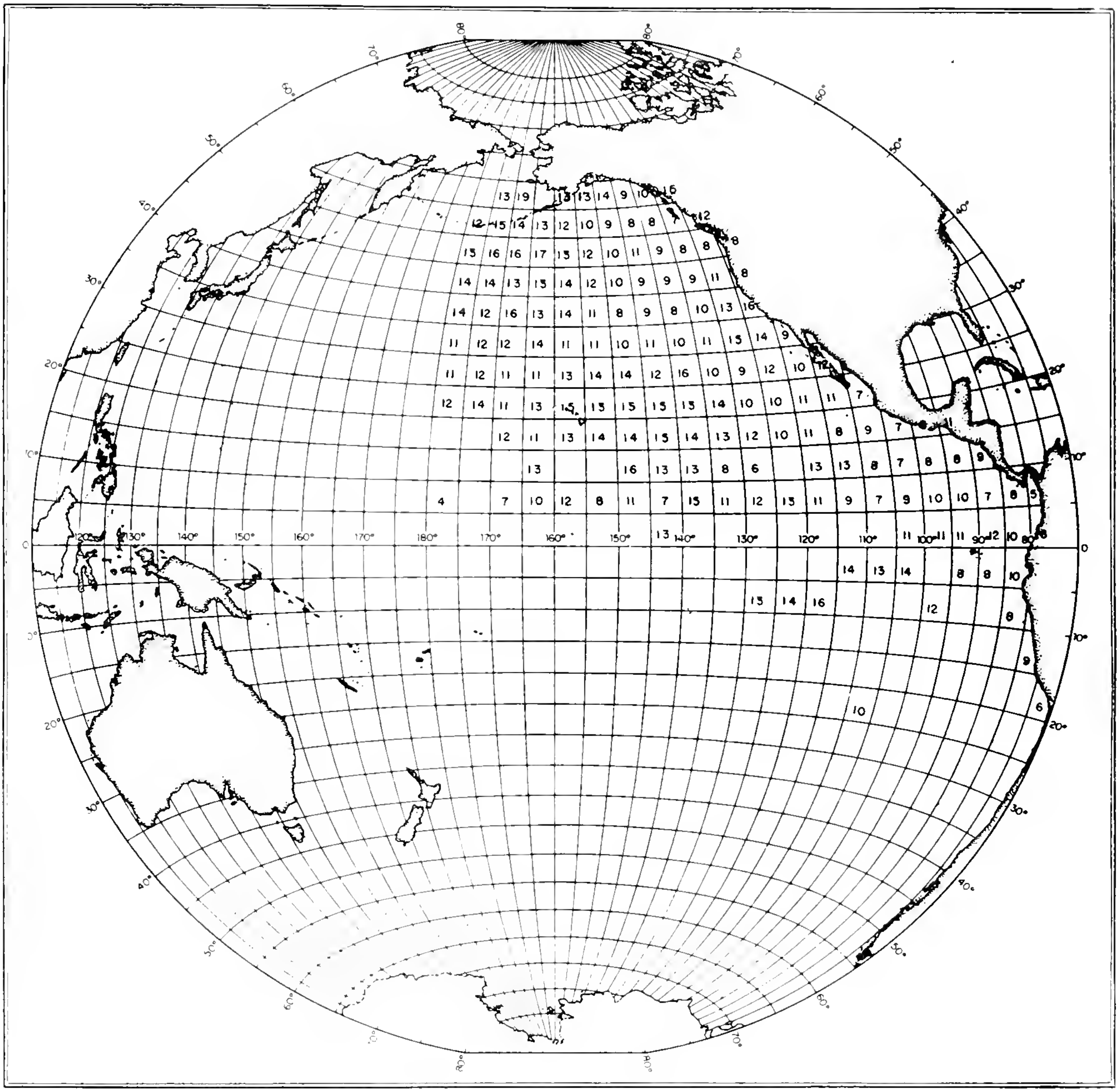

Figure 16.--Wind speed (knots), August 1963.

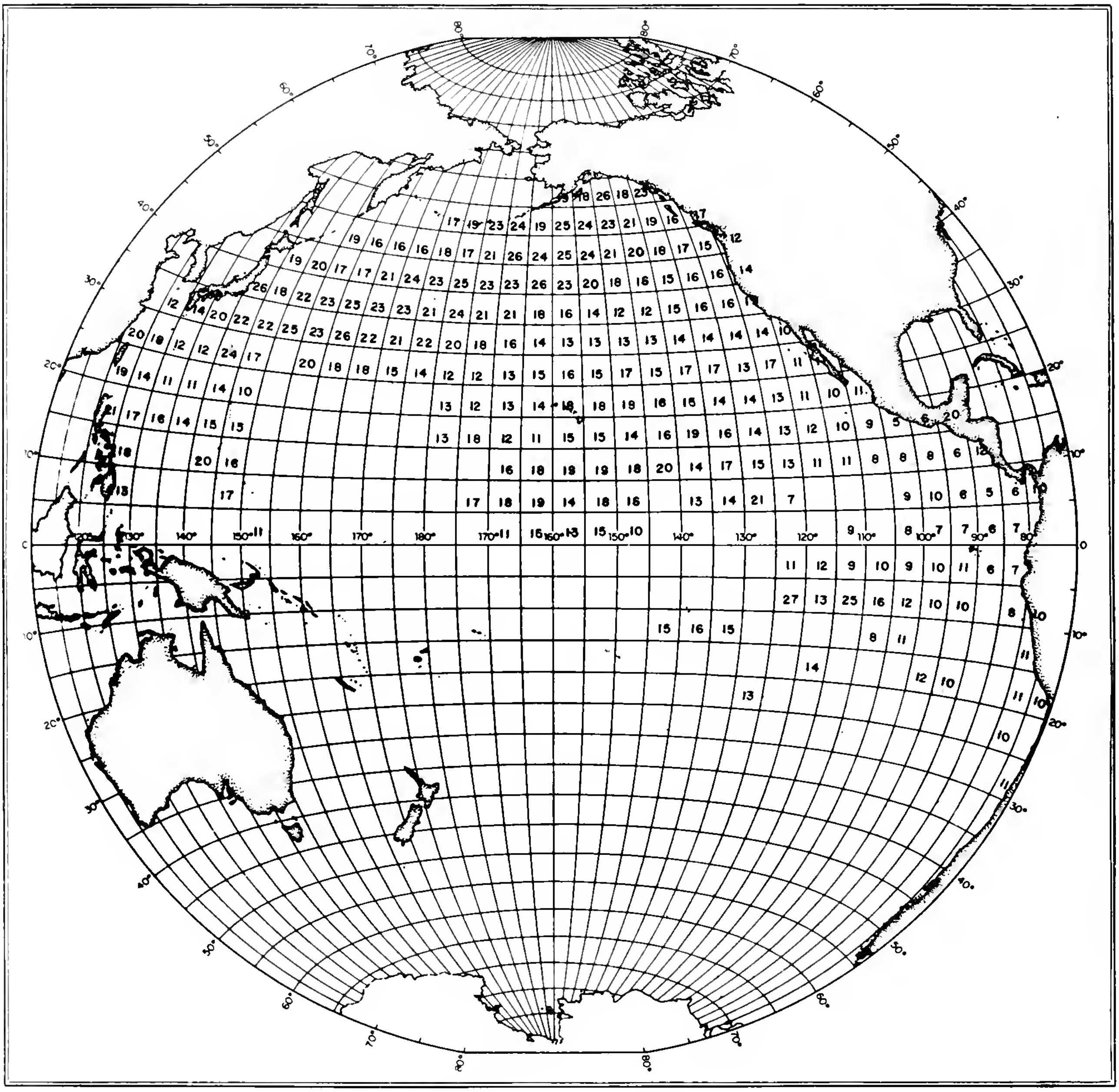

Figure 17.--Wind speed (knots), February 1964.

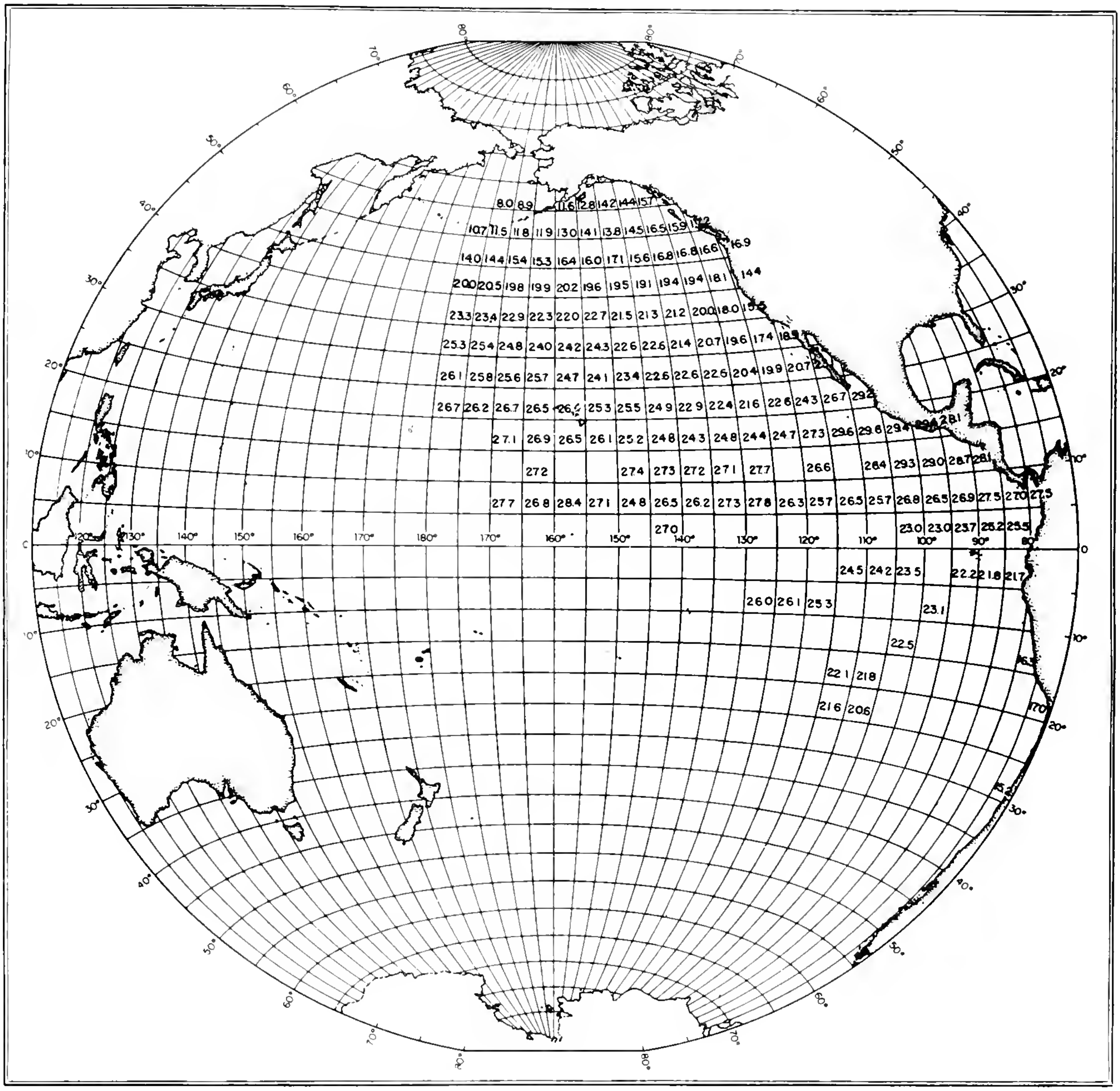

Figure 18.--Air temperature (° C.), August 1963.

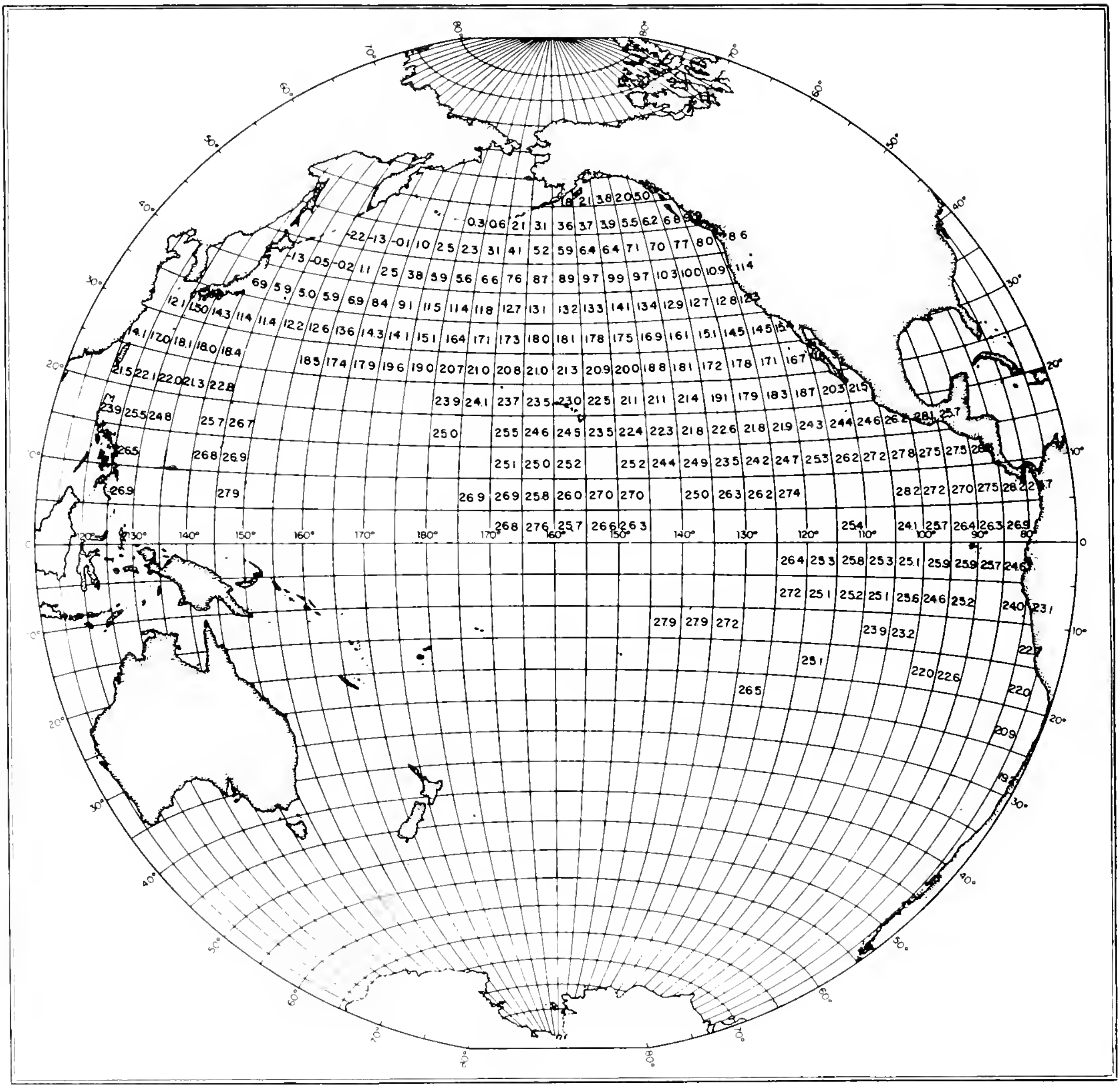

Figure 19.--Air temperature (° C.), February 1964.

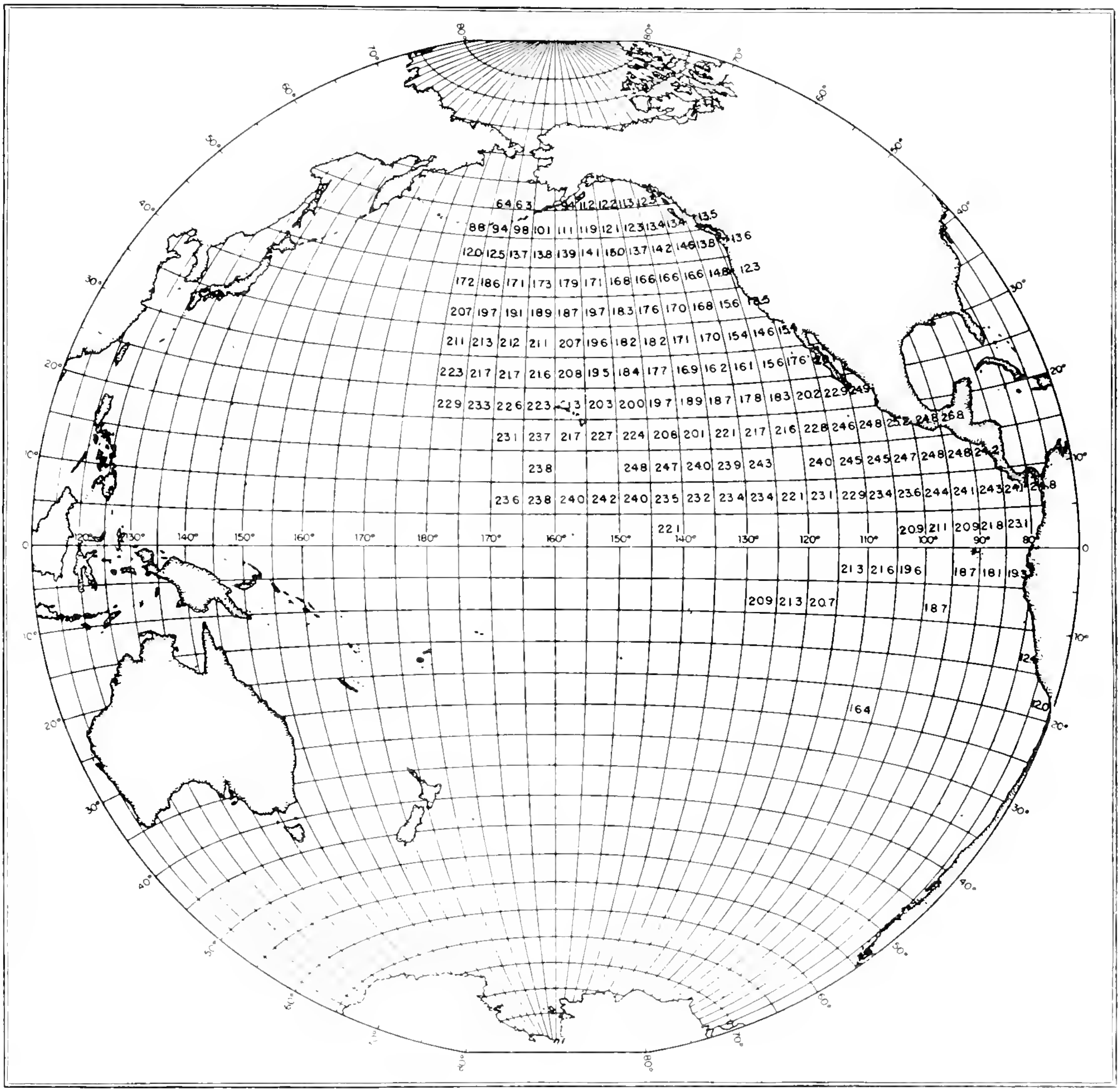

Figure 20.--Dew point temperature (° C.), August 1963.

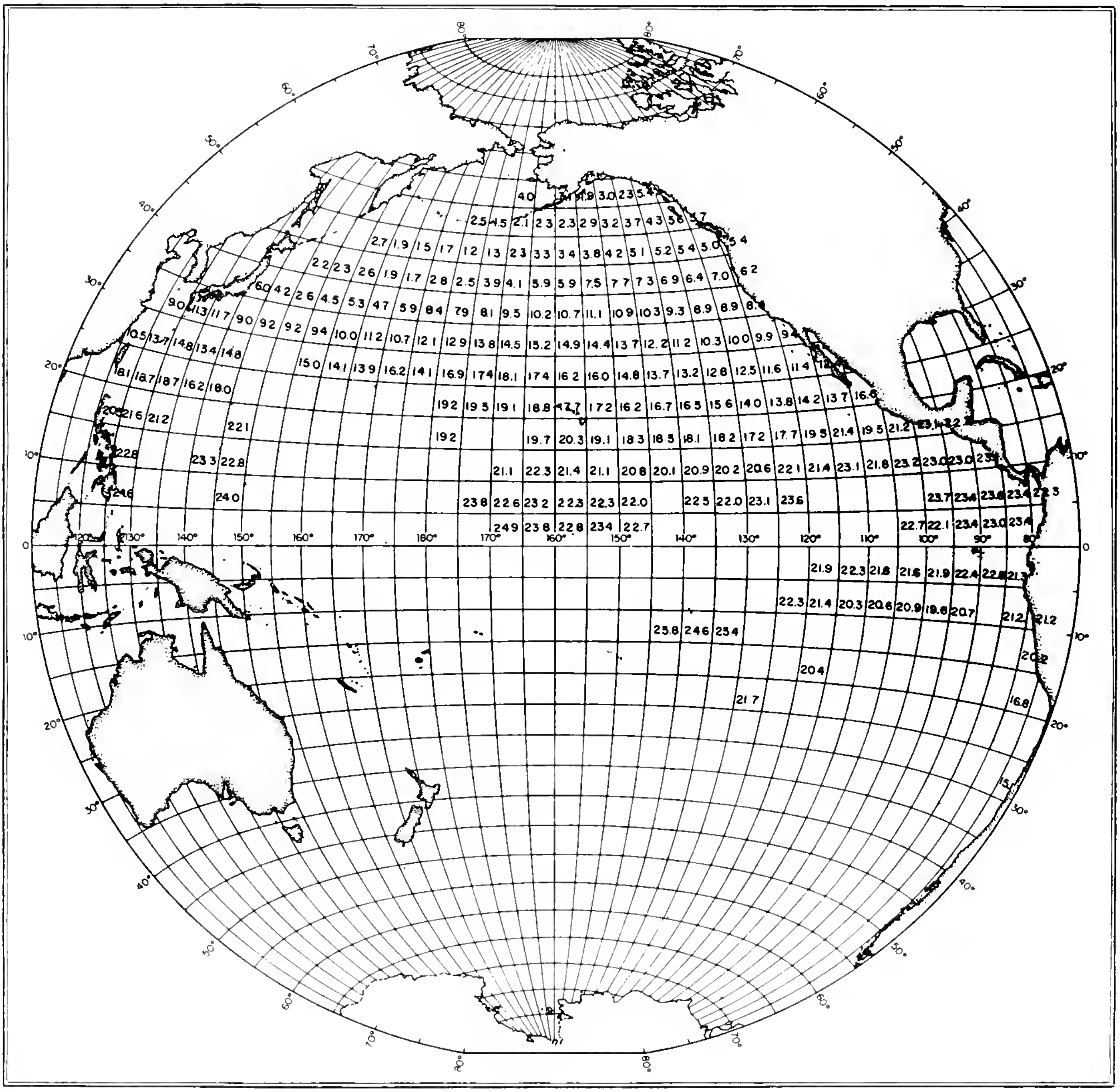

Figure 21.--Dew point temperature (^{O} C.), February 1964.

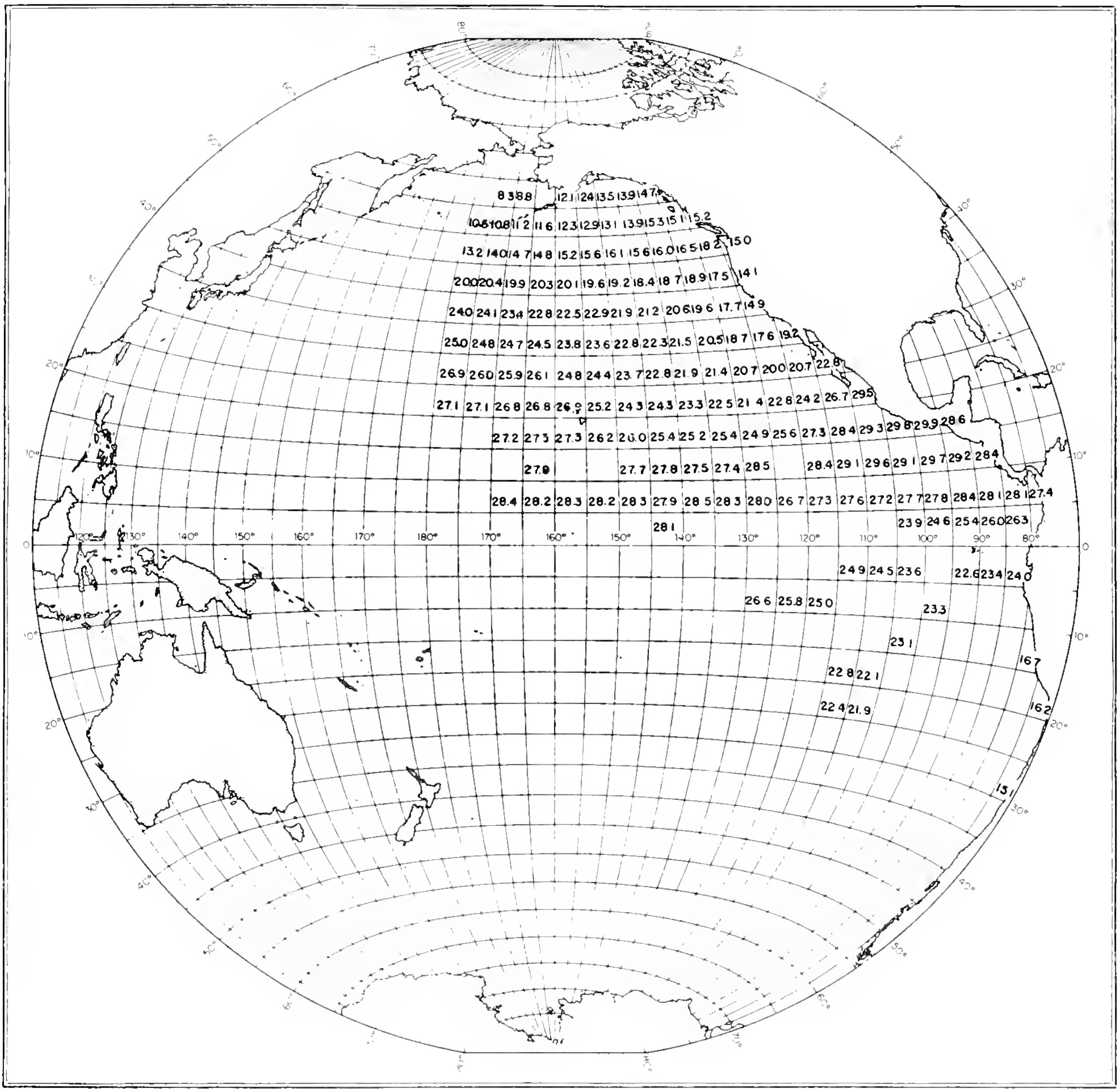

Figure 22.--Sea surface temperature (^{O} C.), August 1963.

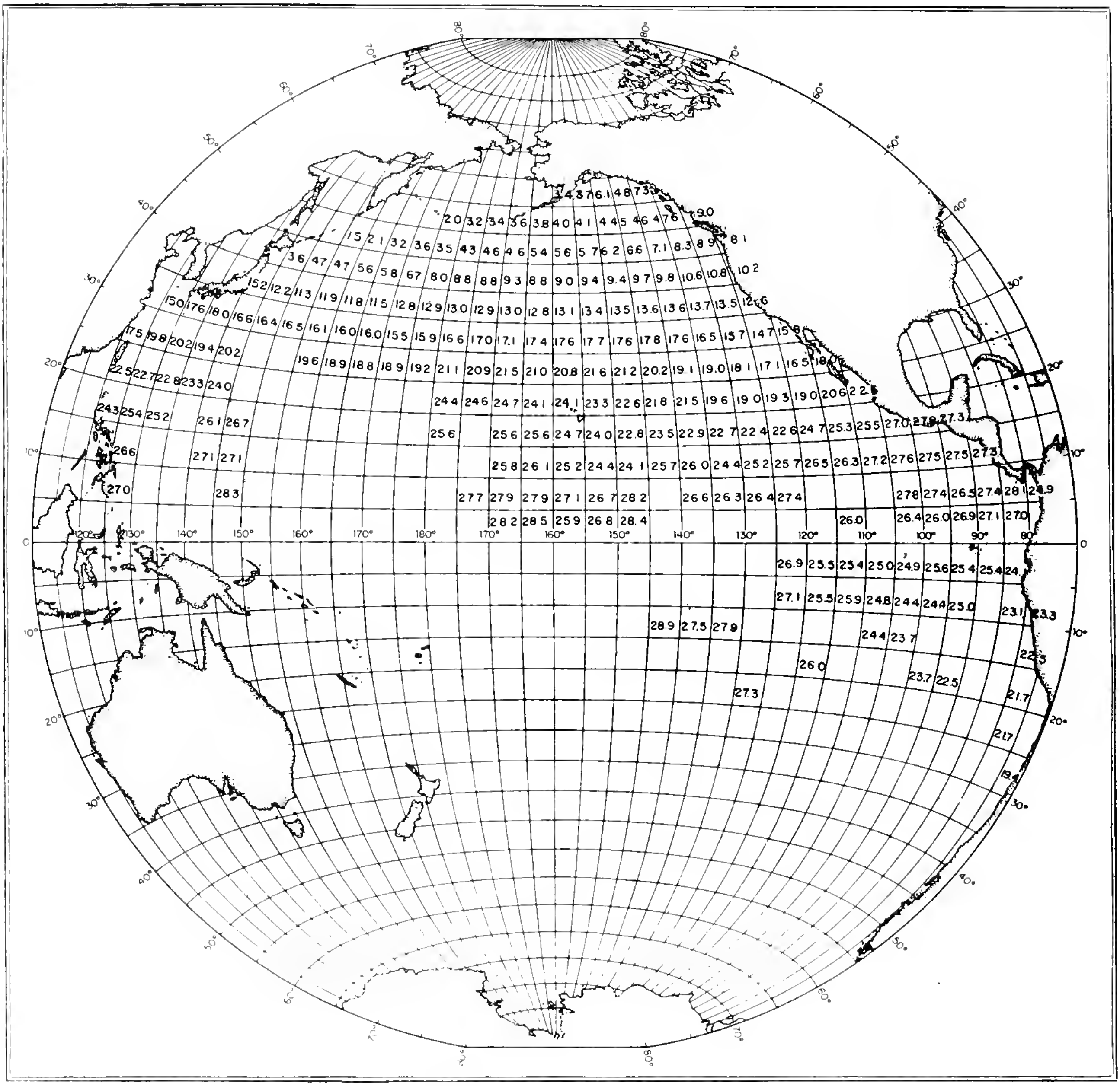

Figure 23.--Sea surface temperature (° C.), February 1964.

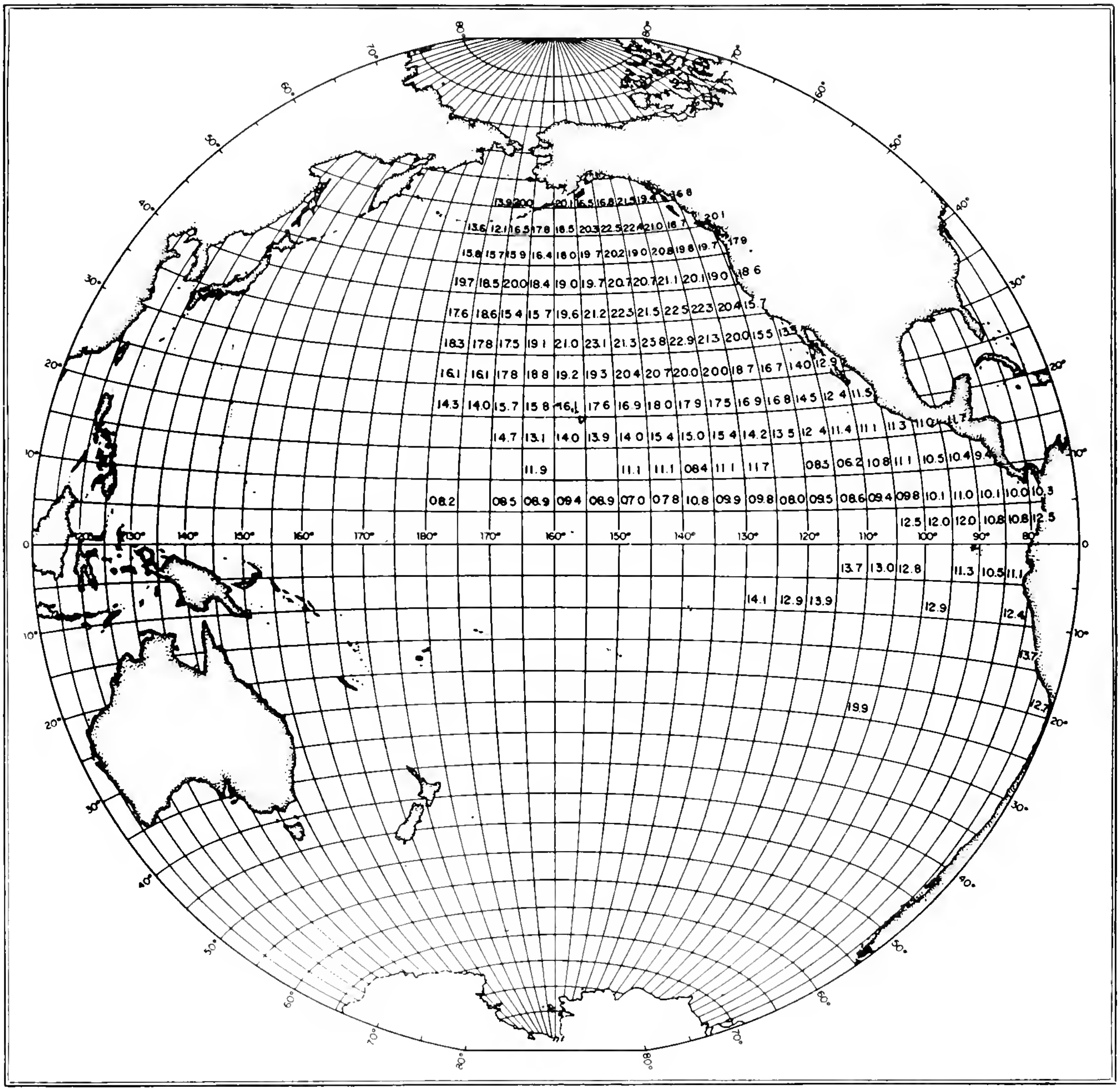

Figure 24.--Barometric pressure (mb.), August 1963.

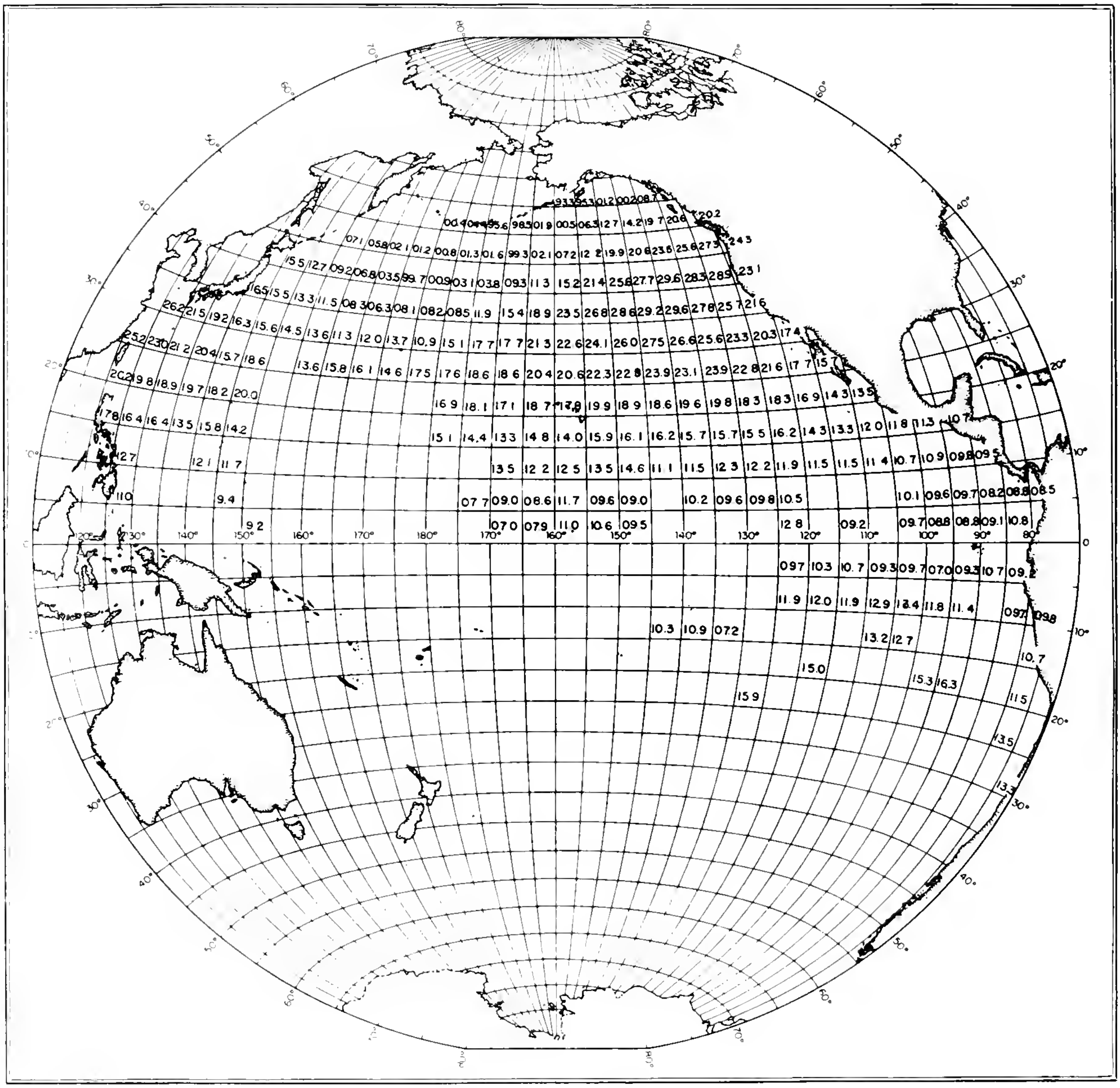

Figure 25.--Barometric pressure (mb.), February 1964.

Of the incoming radiation corrected for the screening effects of cloud cover, some is reflected at the sea surface. The amount reflected depends on the latitude and time of year. The computational expression is as follows:

$$\underline{Q_R} = \underline{Q_1} \times \underline{r}$$

where $\underline{r}$ = percentage of radiation reflected presented in a table by Budyko (1956); this table is listed in Appendix B-2. The percentage varies from about 6 percent in low latitudes to more than 20 percent in high latitudes in winter.

Back radiation, $\underline{Q_B}$ (in cal./cm.^{2}/day), is the difference between long-wave radiation from the sea surface and long-wave radiation from the atmosphere. The following semi-empirical equation proposed by Berliand and Berliand (1952), and used by Roden (1959) for studies of the California Current system, has been incorporated in this study:

$$\underline{Q_B} = \underline{s}\sigma\theta^4_{sea}\,(0.39 - 0.050\sqrt{\underline{e}})\,(1 - \underline{k}\,\underline{C}^2) + 4\underline{s}\sigma\theta^3_{sea}\,(\theta_{sea} - \theta_{air})$$

where $\underline{s}$ = 0.97 - the ratio of the radiation of the sea surface to a black body

θ_{sea} θ_{air} = absolute temperature in ° C.;

σ = 1.175 x 10^{-7} - the Stefan-Boltzmann constant;

$\underline{e}$ = vapor pressure (mb.);

$\underline{k}$ = constant [4];

$\underline{C}$ = cloudiness in tenths.

Off the California coast, Roden (1959) has found that $\underline{Q_B}$ varies from about 80 to 140 cal./cm.^{2}/day and Seckel (1962) has found that, in the Hawaiian Islands region, values range from 115 to 150 cal./cm.^{2}/day. At Triple Island, British Columbia, and at ocean station "Papa," Tabata (1958, 1961) has recorded average values of about 100 cal./cm.^{2}/day with little seasonal variation.

The incoming radiation corrected for cloud cover minus that which is reflected and lost by back radiation may be called the "effective" radiation. Additional energy enters or leaves the sea surface as evaporation ($\underline{Q_E}$) and sensible heat ($\underline{Q_H}$). Jacobs (1951) discussed evaporation and conduction of sensible heat at length and presented seasonal charts of these values for the north Pacific Ocean.

Evaporation depends upon (1) the velocity of the wind and of the vapor pressure difference between the sea surface and air above it, and (2) a constant coefficient of proportionality. There is little agreement as to the value of the constant that should be used; the one selected for our computations is given by Tabata (1958):

[4] Values for $\underline{k}$ are given in Appendix table B-3.

$$\underline{Q_E} = 4.70\,(\underline{e_s} - \underline{e_a})\,\underline{W}$$

where $\underline{e_s}$ = vapor pressure at temperature of sea surface (mb.);

$\underline{e_a}$ = vapor pressure of air (mb.);

and $\underline{W}$ = wind speed (m./sec.).

Appendix Table B-4 lists values of saturation vapor pressure over water used in computation of evaporation.

In general, regions of greatest evaporation are those wherein northerly transport of surface water is greatest and which are subjected during winter to frequent invasions by cold, dry air masses from the interiors of continents. In the Pacific, this region is situated off Japan where cold dry air of continental Asiatic origin frequently traverses the northward-flowing, warm Kuroshio Current. Another region of high evaporation is in the trade wind zone as a result of relatively strong winds and dry, descending air associated with the semipermanent fields of high pressure (Jacobs, 1951). A region of low evaporation, in contrast, is in the eastern Pacific over the southward-flowing, cool California Current.

Bowen (1926) established the relation between evaporation and the heat exchange at a water surface. The equation used here is derived from the relation found by Bowen:

$$\underline{Q_H} = 3(\underline{T_s} - \underline{T_a})\,\underline{W}$$

where $\underline{T_s}$ = sea temperature (° C.);

$\underline{T_a}$ = air temperature (° C.);

and $\underline{W}$ = wind speed (m./sec.).

Values of sensible heat exchange are generally low in summer and relatively high in winter but nowhere approach the magnitude of heat flux through evaporation.

Caution must be exercised in interpreting the energy exchange values in regions having limited observational coverage. Small errors in observation and transmission can cause large errors in some of the computations. In quadrangles having few observations, considerable bias can be introduced by the relative positions of the reporting ships and their timing with respect to the calendar month. All computations presented below assume the data centroid to be at the center of each respective quadrangle and for the middle of the calendar period involved. Energy exchange calculations are not performed for 5-degree quadrangles having fewer than five observations per month, though summarized meteorological data are listed.

Representative charts of the seasonal variation of total energy exchange and its components are presented for August 1963 and February 1964 in figures 26-37.

Until further experiments on the nature of the heat flux at the air-sea interface are completed, equation models are refined, and the

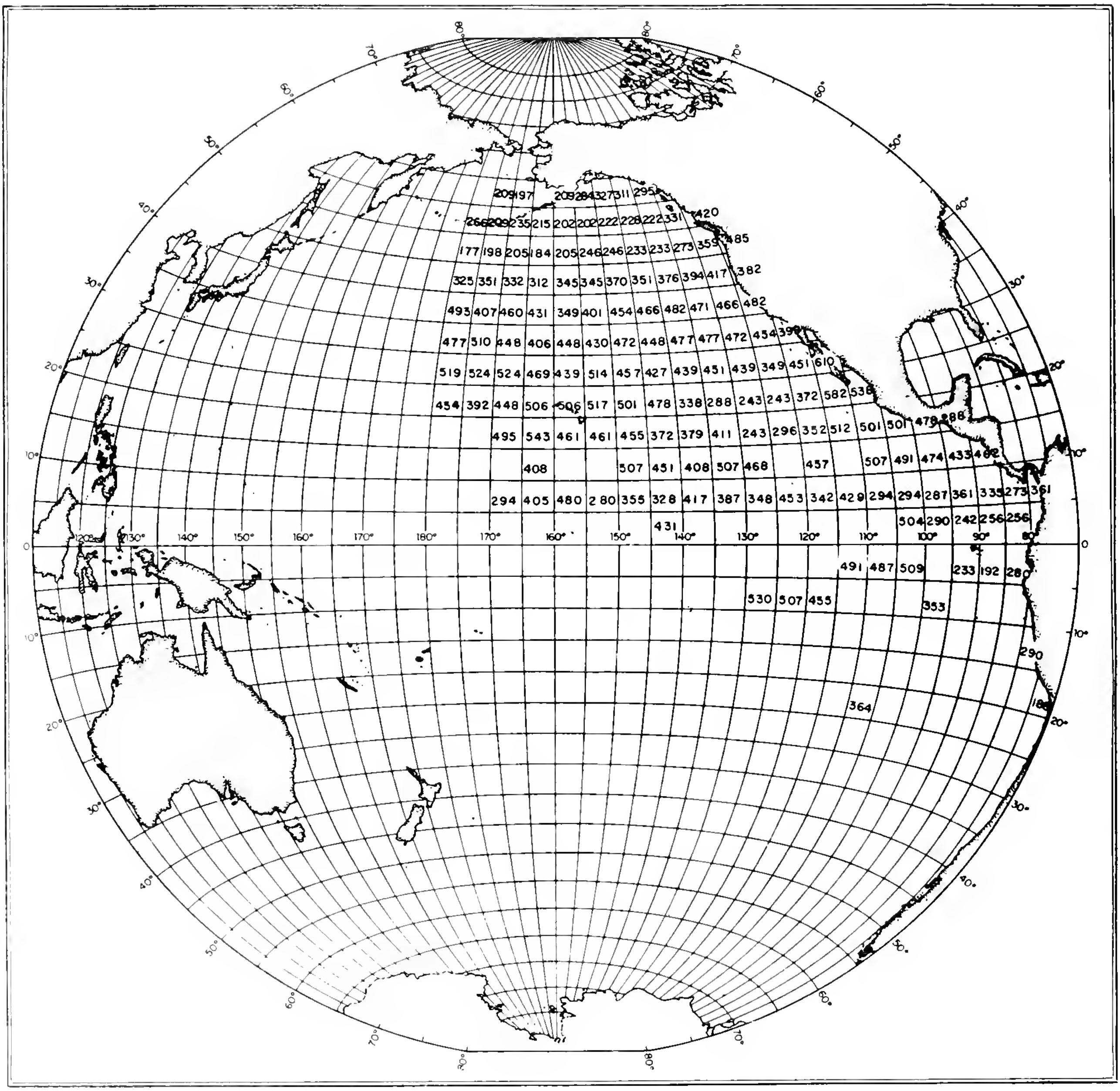

Figure 26.--Incoming radiation (cal./cm.^{2}/day) corrected for cloud cover, August 1963. All values positive.

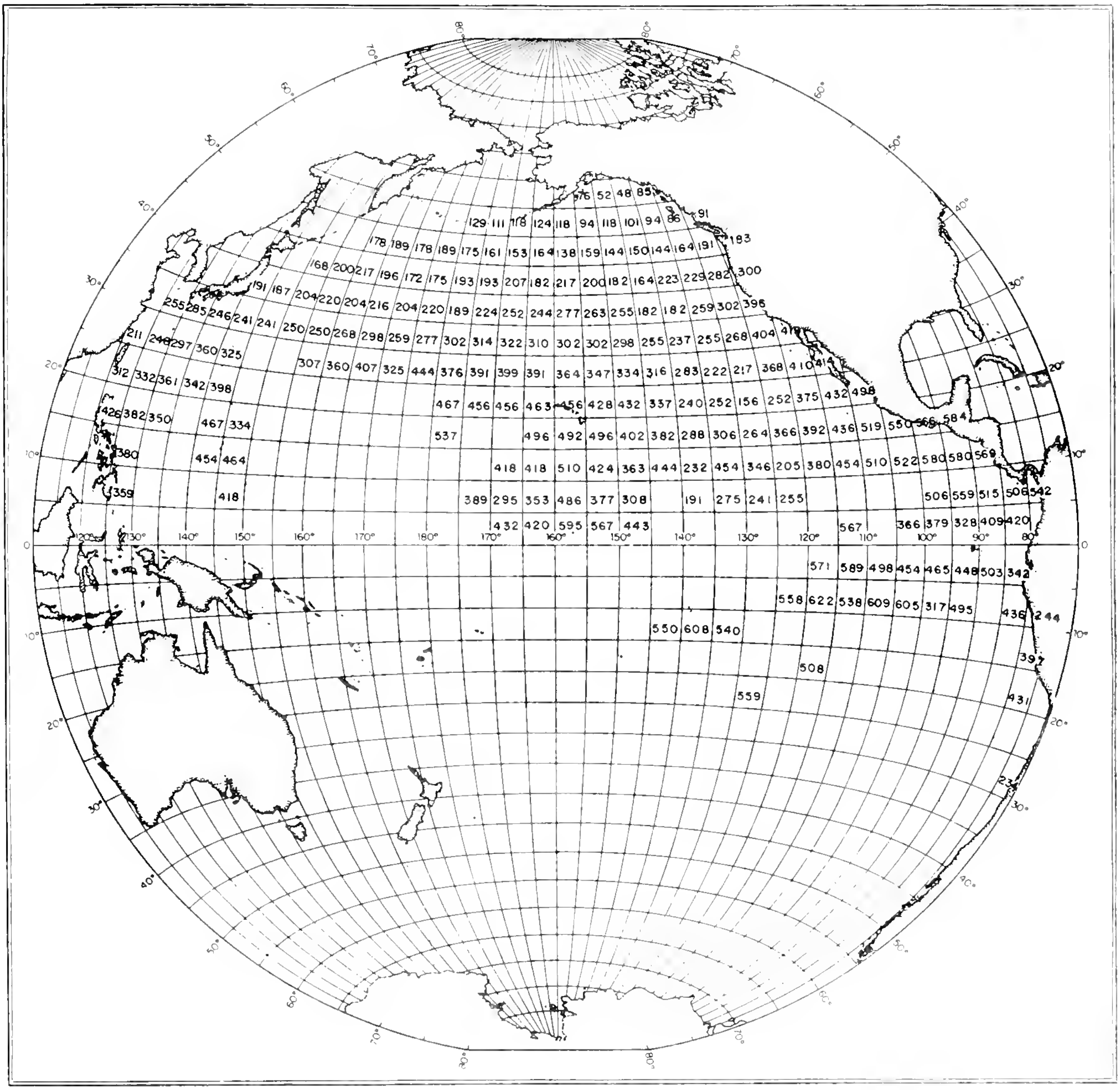

Figure 27.--Incoming radiation (cal./cm.^{2}/day) corrected for cloud cover, February 1964. All values positive.

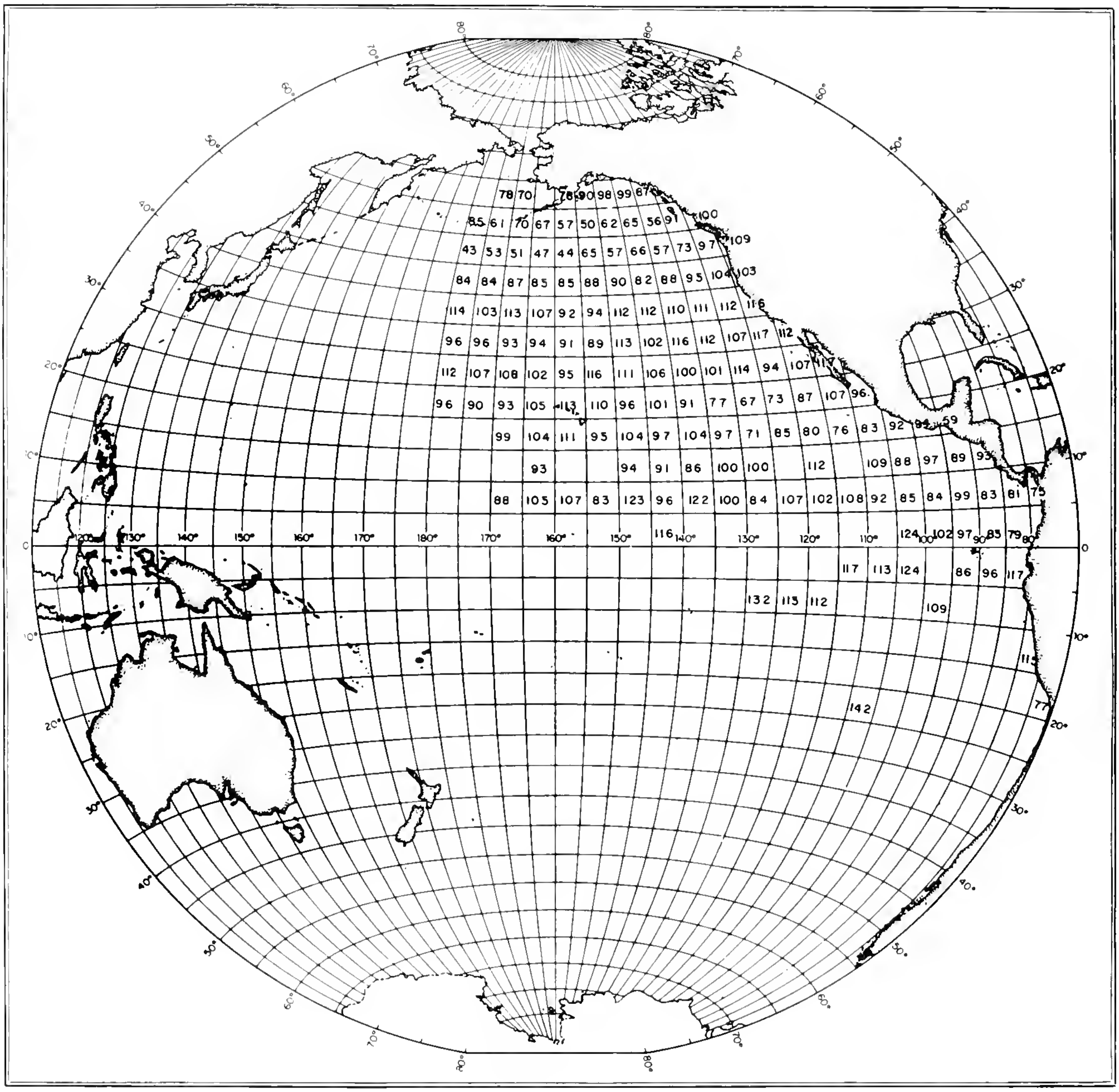

Figure 28.--Back radiation (cal./cm.²/day), August 1963. All values negative.

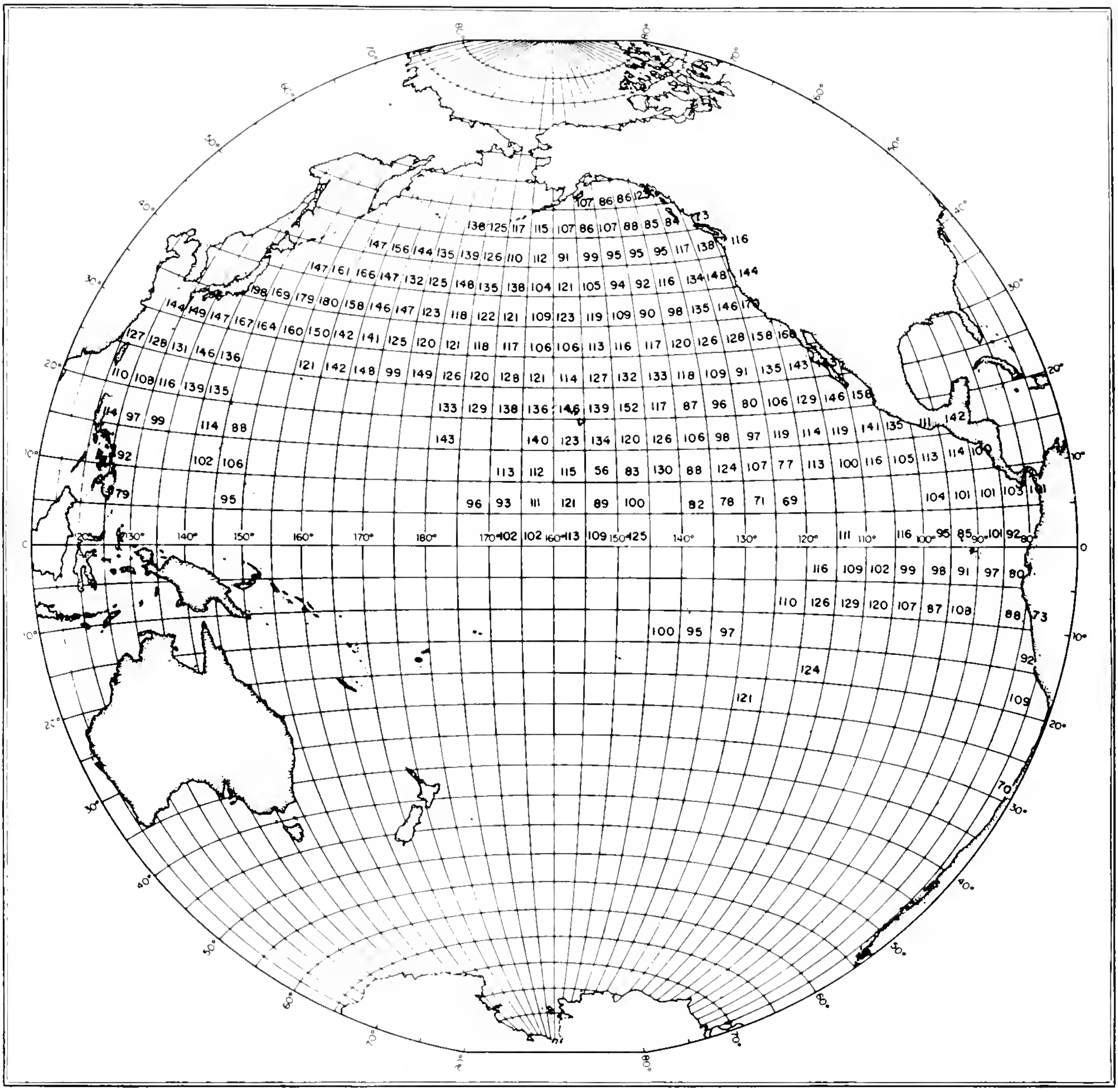

Figure 29.--Back radiation (cal./cm.^{2}/day), February 1964. All values negative.

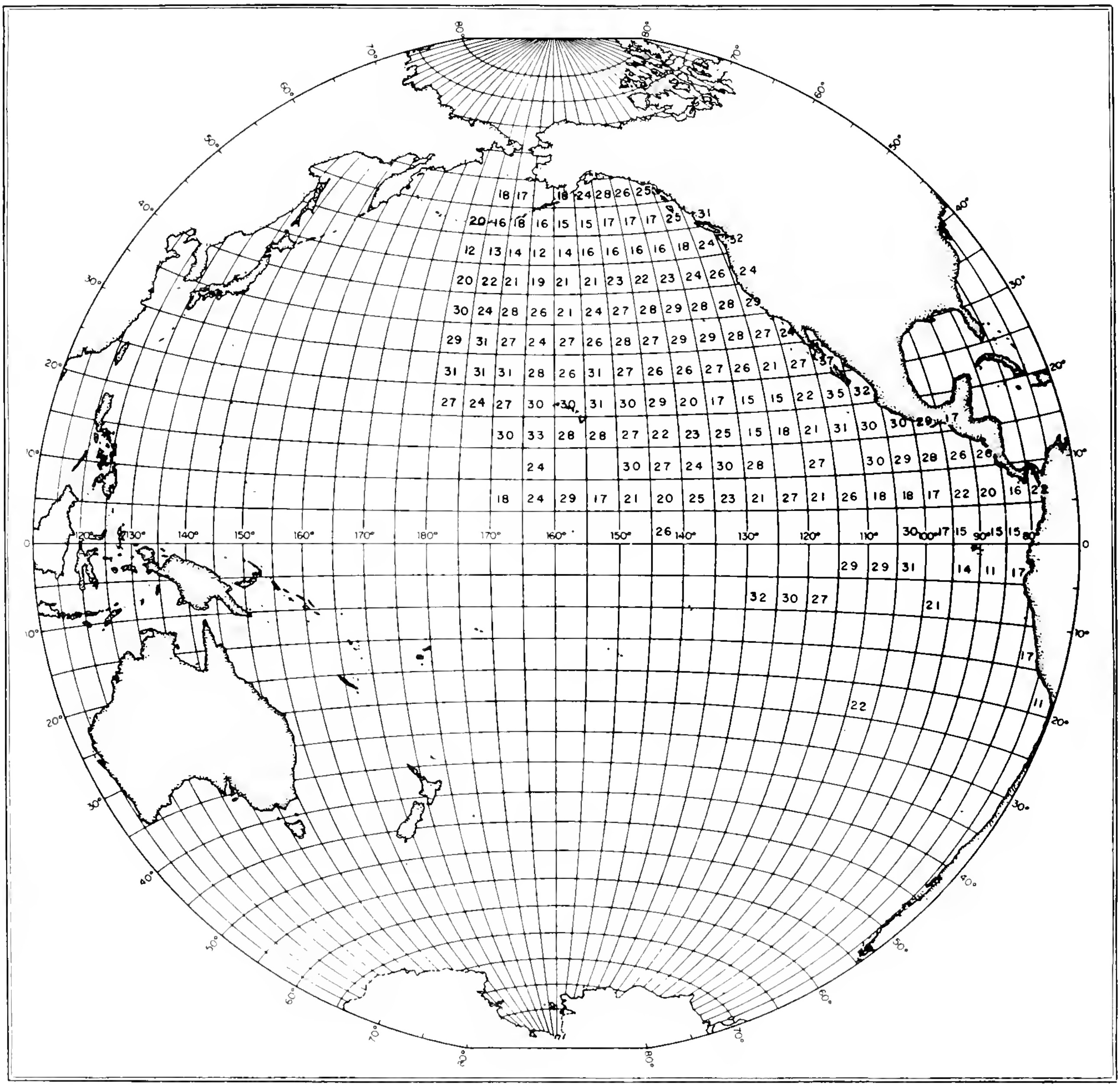

Figure 30.--Reflected radiation (cal./cm.^{2}/day), August 1963. All values negative.

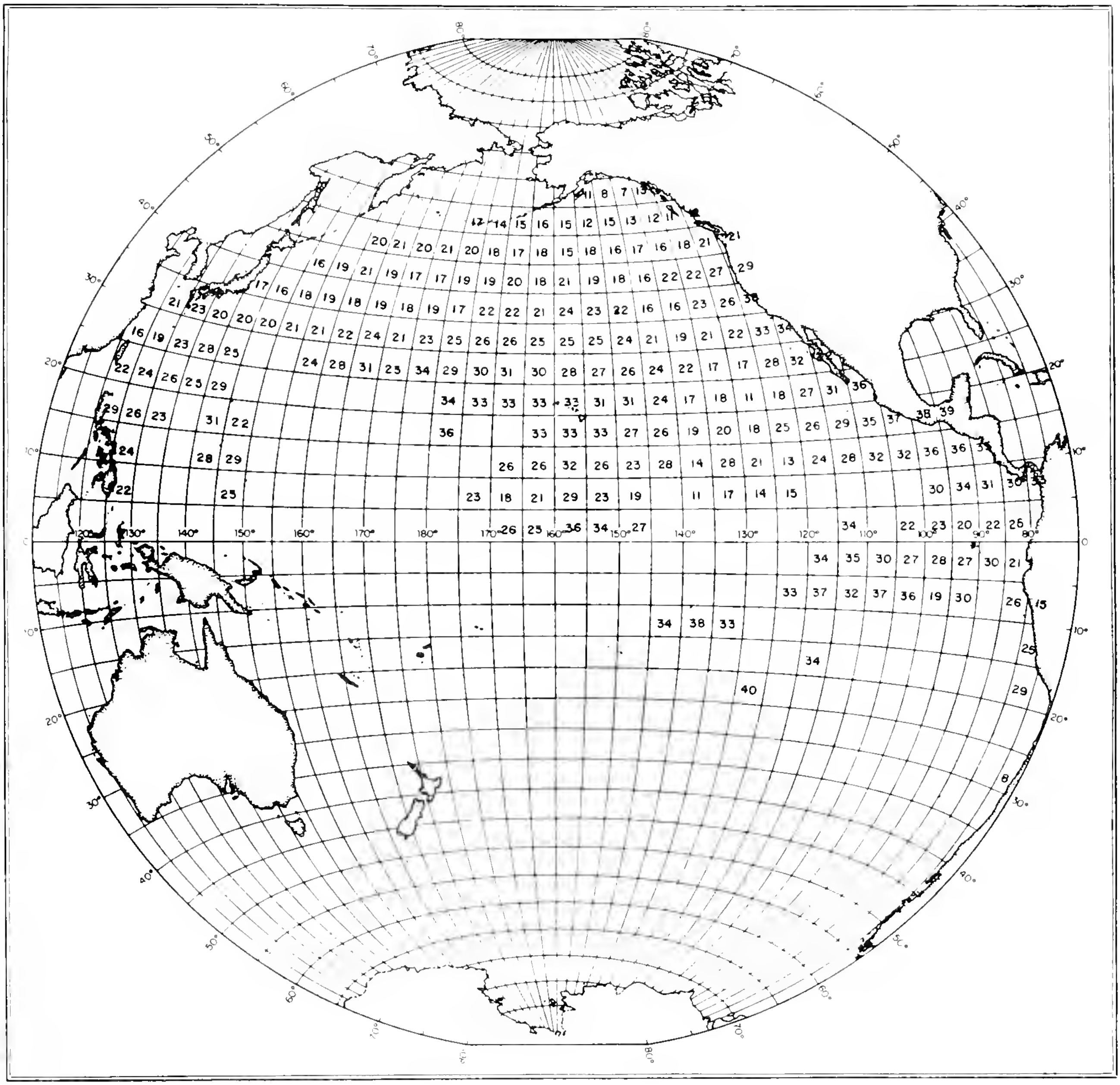

Figure 31.--Reflected radiation (cal./cm.^{2}/day), February 1964. All values negative.

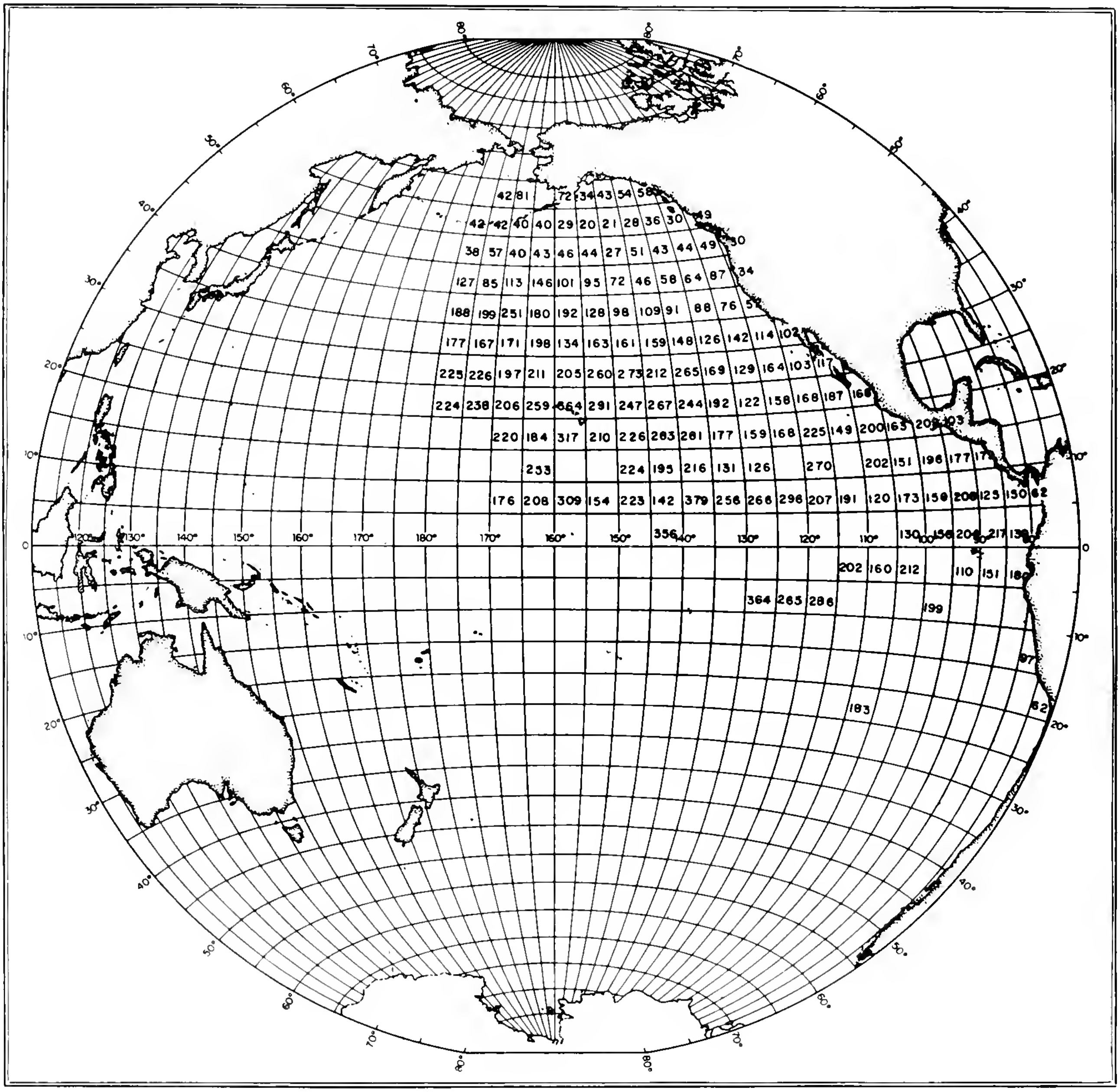

Figure 32.--Evaporation (cal./cm.^{2}/day), August 1963. All values negative.

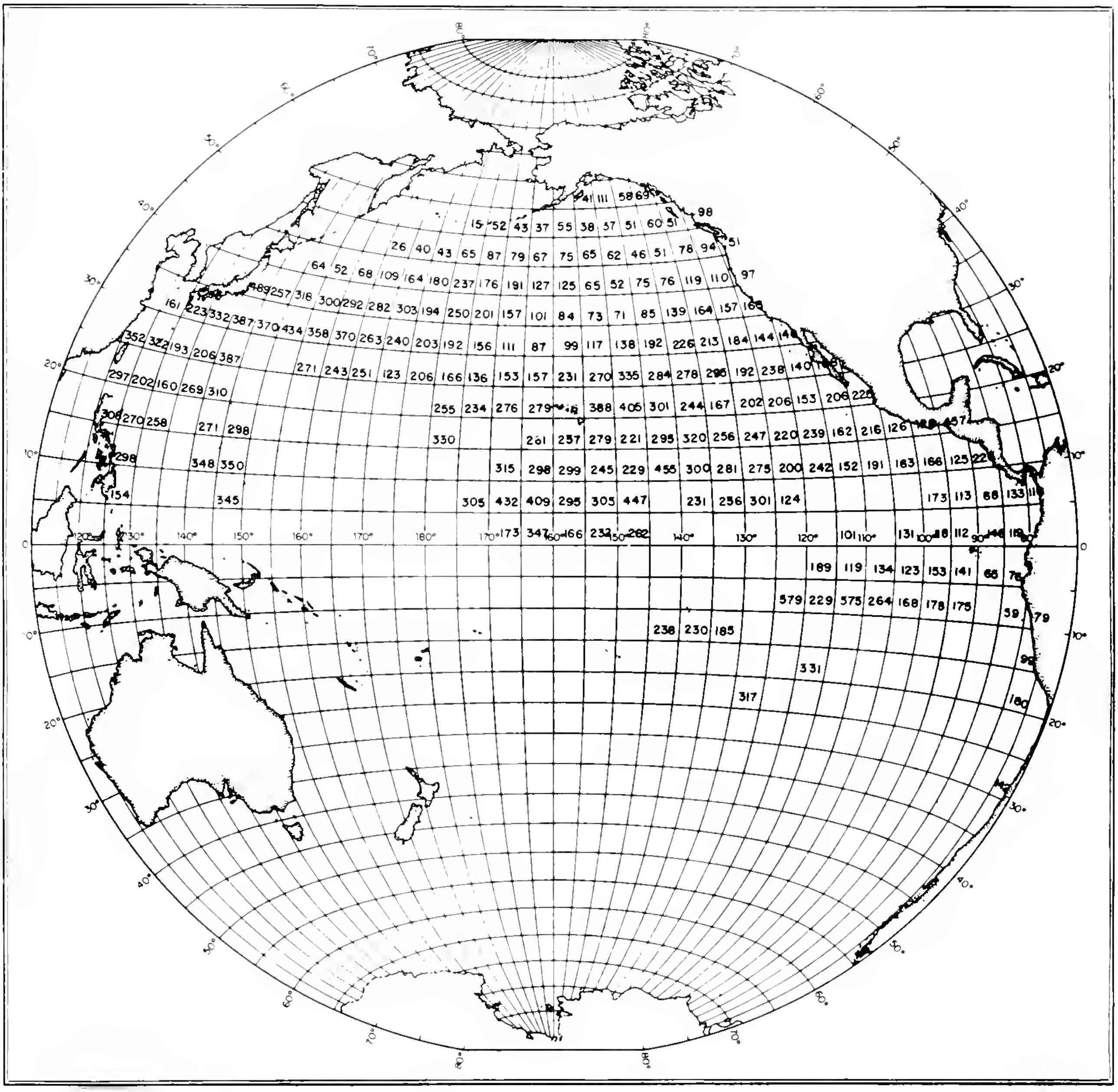

Figure 33.--Evaporation (cal./cm.^{2}/day), February 1964. All values negative.

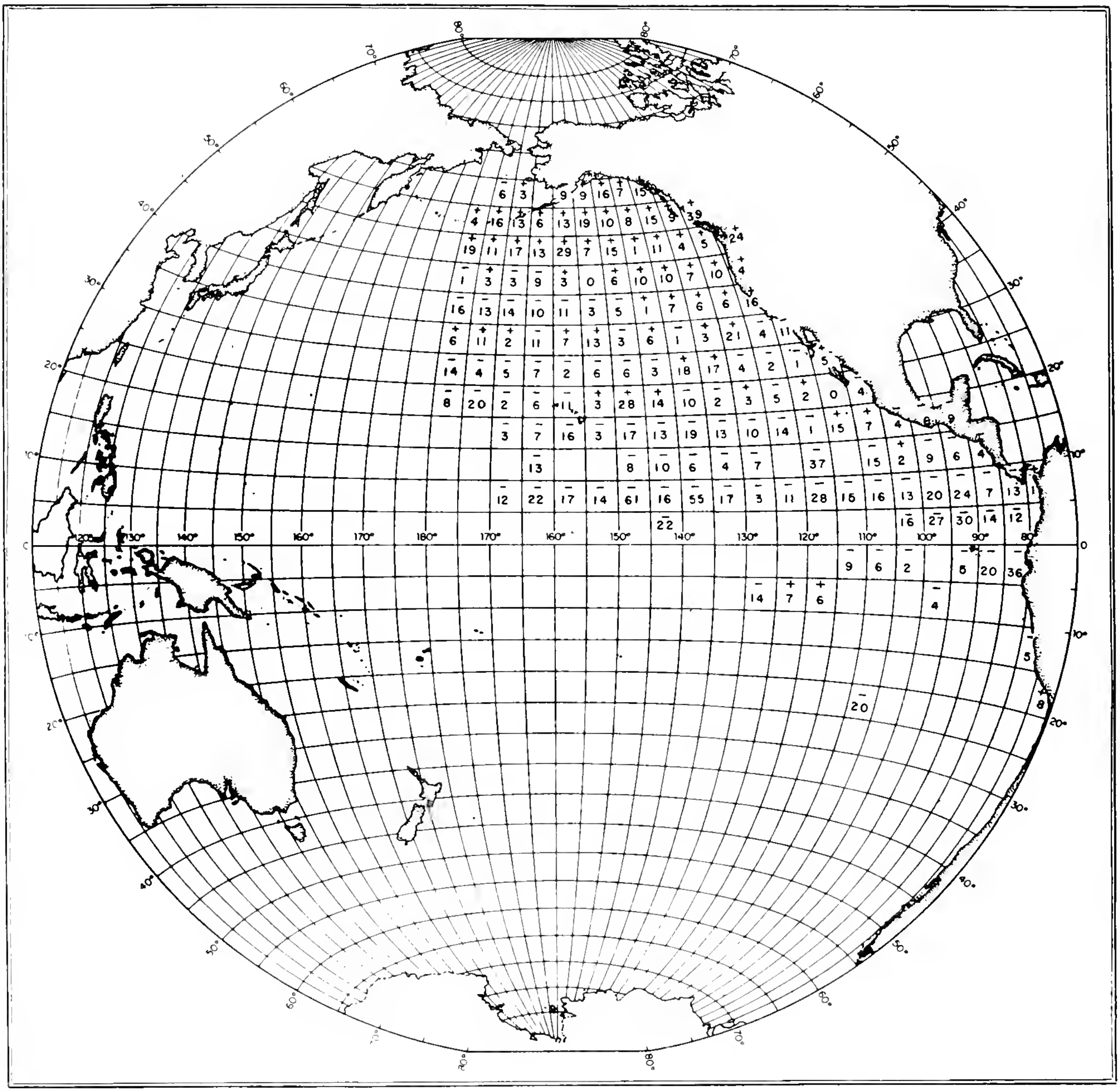

Figure 34.--Conduction of sensible heat (cal./cm.^{2}/day), August 1963.

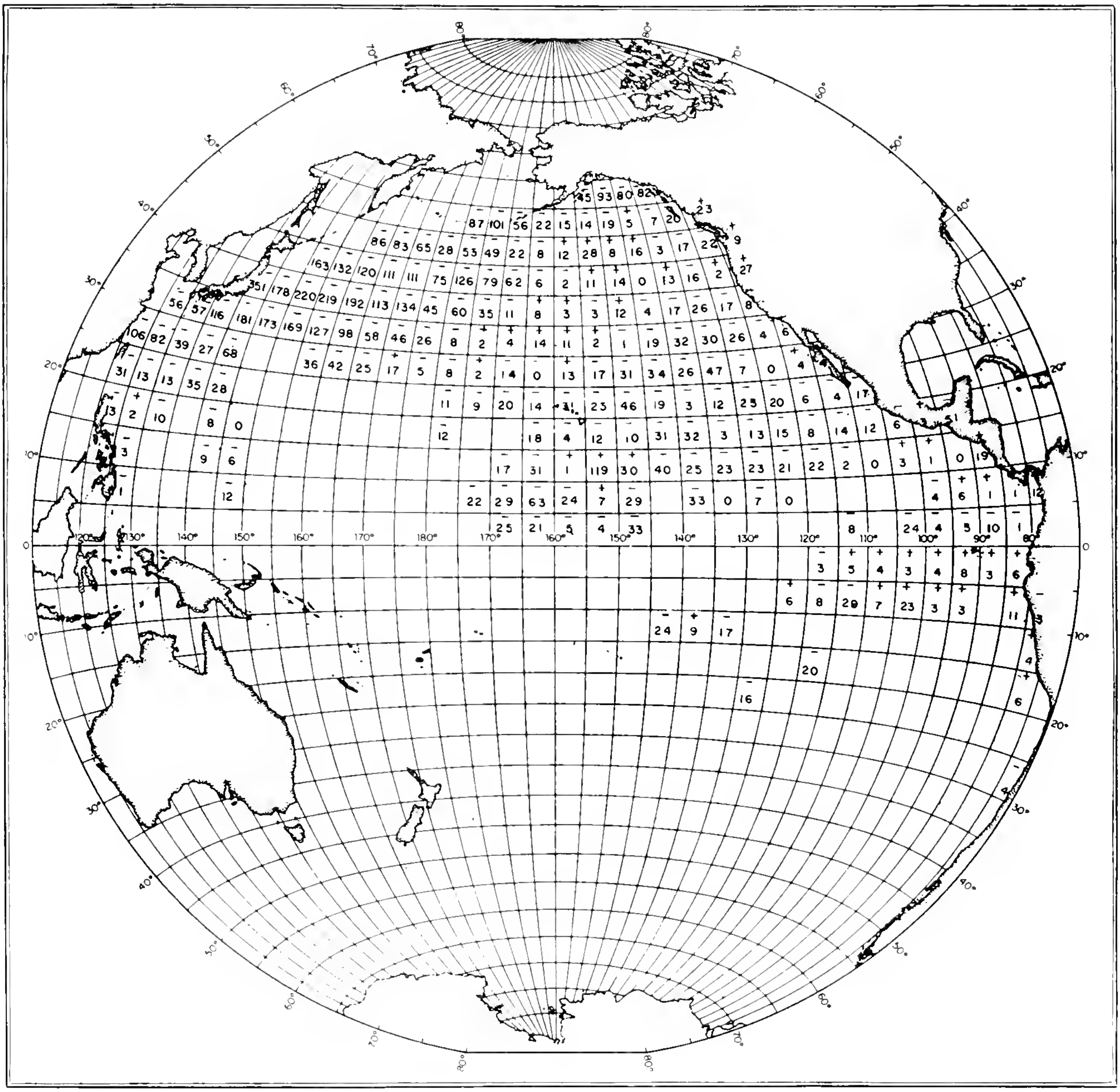

Figure 35.--Conduction of sensible heat (cal./cm.^{2}/day), February 1964.

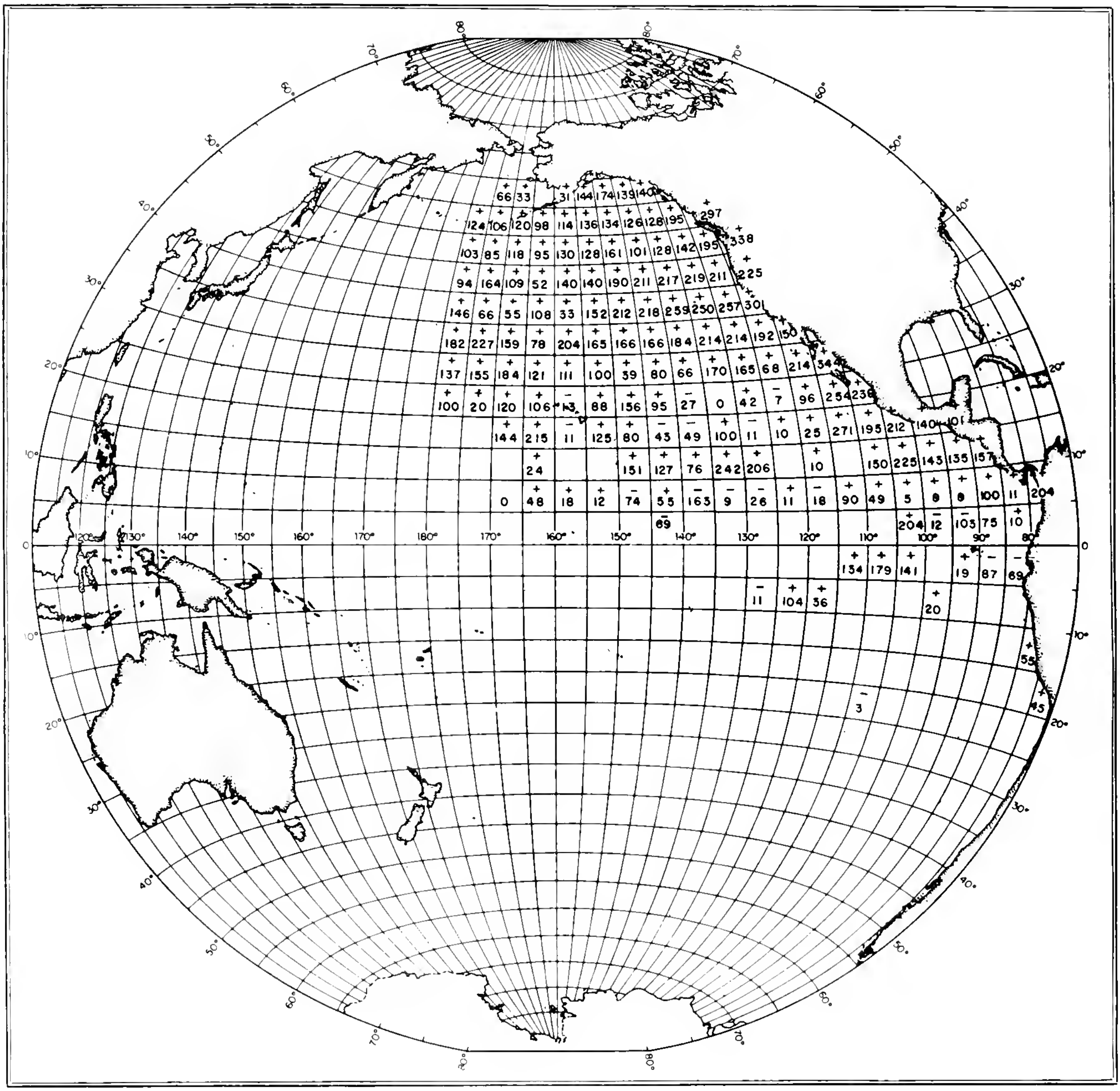

Figure 36.--Total energy exchange (cal./cm.^{2}/day), August 1963.

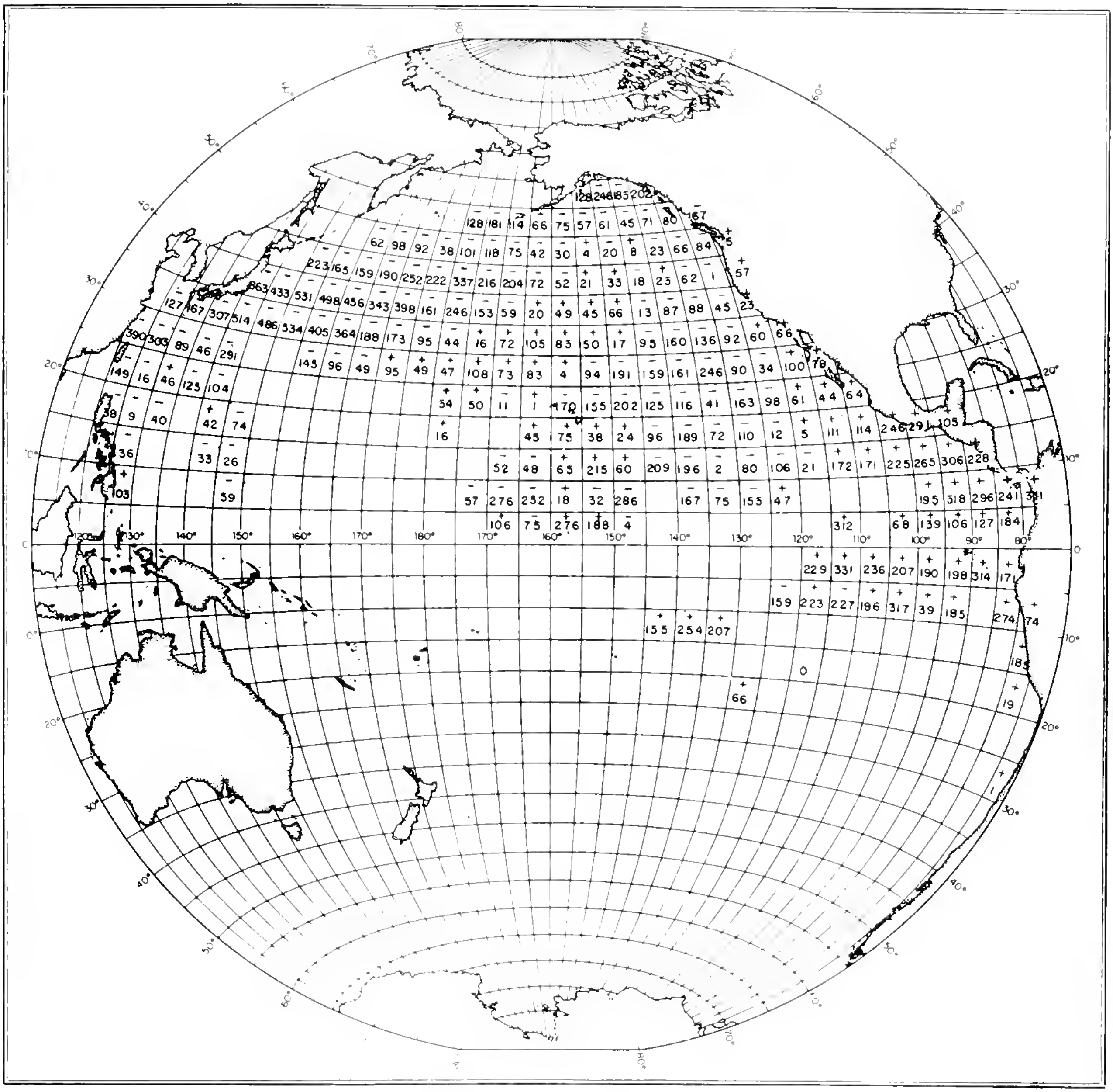

Figure 37.--Total energy exchange (cal./cm.^{2}/day), February 1964.

accuracy of the synoptic marine weather report is improved, only broad scale features of the energy exchange will be considered. The real value of the heat budget charts as presented may be in showing year to year and month to month variations of each parameter.

Until such time as these computations can be improved more adequately to represent absolute values, they should be considered only as relative indices of the magnitude of the total energy flux which is taking place at the air-sea interface. On this basis, the data that are being produced routinely on a monthly schedule should stimulate further research efforts in this general subject area.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to John W. Martin, who developed the first machine-language program to summarize sea temperatures and portions of the meteorological data. Members of the Computer Center, University of California, San Diego, and its director, Clay L. Perry, assisted in resolving certain technical problems encountered during initial development of the program.

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APPENDIX A

Listing of the FORTRAN-62 data processing program for synoptic marine weather reports conforming to the World Meteorological Organization code format FM 21.A., International Surface Report from Ship in Full Form.

```
-COOP,BAA1-001,CLINE,1/10/20/30/0/20/30,40,18000,,NANCY.
-BINARY,56.
(RELOCOM.
-FORTRAN,0,1,56.
      PROGRAM BUCOM
      DIMENSION MEANSEA(72,24), MEANBAR(72,24), ISEATEMP(10,120),
     1 IBAROM(10,120), IWINDIRX(10,120), IWINDIRY(10,120), IWINDVEL(10,
     2 120), ISEA(10,120), IBAR(10,120), IWIND (10,120),
     3   IWINDV(10,120), IREJT(10,120), IREJB(10,120), ITEMPREJ(10,120)
     4 , IBAROREJ(10,120), JCLOUD(2,24), JDEWPT(2,24), JCLO(2,24),
     5 JDEW(2,24), JSEA(5,60), KSEA(2,24), KWIND(2,24), KWINDV(2,24),
     6 KSEATEMP(2,24), KWINDVEL(2,24), KWINDIRX(2,24), KWINDIRY(2,24),
     7 JSEATEMP(5,60), COUNT(2,24), DIFF(2,24),KBAROM(2,24),KBAR(2,24),
     8 XK2(24),   ALPHA(21),   BLANK(10),  ES(10,40),
     9 IC1(10),  IREJ(30), XK1(24), HEAT(12,24), REFLECT(12,24)
      DIMENSION XREJ(30),XIC2(10), IBUFFER1(15),
     1 XIC4(2), IC7(2), IC8(2), XIC9(2), IC10(2), CLOUD(2),
     2 QR(2), QI(2), QE(2), QB(2), QH(2), QT(2),   HEAD(120), AHEAD(360)
     3 ,  IC2(10), BAROM(10), IC3(10), IC4(10), IC5(10), IC6(10),
     4 HEAD2(60), AHEAD2(180), HEAD5(24), AHEAD5(72),XNAME(3),TABLE(6)
     5 , AIRTEMP(2)
      COMMON                        ISEATEMP, IBAROM, IWINDIRX, IWINDIRY,
     1 IWINDVEL, ISEA, IBAR, IWIND, IWINDV, IREJT, IREJB, ITEMPREJ,
     2 IBAROREJ, JCLOUD, JDEWPT, JCLO, JDEW, JSEA, KSEA, KWIND,
     3 KWINDV, KSEATEMP, KWINDVEL, KWINDIRX, KWINDIRY, JSEATEMP, COUNT,
     4 DIFF,KBAROM,KBAR
      COMMON  XREJ, XIC2, IBUFFER1, XIC4, IC7, IC8, XIC9, IC10, CLOUD,
     1 QR, QI, QE, QB, QH, QT, HEAD, AHEAD, IC2, BAROM, IC3, IC4, IC5,
     2 IC6, HEAD2, AHEAD2, HEAD5, AHEAD5, XNAME, TABLE, AIRTEMP,
     3        XK2, ALPHA, BLANK, ES, IC1, IREJ, XK1, HEAT, REFLECT,
     4 MEANSEA, MEANBAR
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     TABLES FORMATS...
   10 FORMAT(12F6.2)
   11 FORMAT(20A4)
   12 FORMAT(12F6.0)
   13 FORMAT(10F8.2)
   14 FORMAT(12I6)
   15 FORMAT(8I10)
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     HEADER CARD FORMAT...
   16 FORMAT(I1, A1, 8X, I1, A1, 8X, I2, A1, 7X, I2, A1, 7X, I2, 8X,
     1  A8, 1X, I4, 6X, 2I1)
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     ALPHAMERIC FORMATS...
   17 FORMAT(6X, A1, A2, 2X, A2, 4X, A1, 2A2, 1X, A2, 4X, A3, A2, 13X,
     1  3(A1, 2A2, 1X), 3A5)
   18 FORMAT(4X, A1,   9(5X, A1))
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     OUTPUT FORMATS, HEADINGS...
   19 FORMAT(1H1,22X,75HU.S. BUREAU OF COMMERCIAL FISHERIES    SYNOPTIC
     1WEATHER DATA--PACIFIC OCEAN /)
   20 FORMAT(1H0,29X,15HLATITUDE RANGE ,A4,1H-,A4,12X,16HLONGITUDE RANGE
     1 ,A4,1H-,A4/ 3(1H0   /) )
   21 FORMAT(1H0,8X,9HLONGITUDE ,2X,10(A4,6X) /9H LATITUDE )
   22 FORMAT(1H0,8X,9HLONGITUDE,12X,4(A4,16X),A4/9H LATITUDE   )
   23 FORMAT(1H0,8X,9HLONGITUDE,42X,A4,46X,A4 /9H LATITUDE   )
C     TEMPS ONLY...
   25 FORMAT(2H0 A4, 10X, 10(2X,F2.0,1X, 1H(, I2, 1H) , 1X)   )
C     TEMP REJECTS...
   26 FORMAT(2H0 A4, 10X, 10(1X,F2.0,1X,F2.0,1X,F2.0,1X)   )
C     BAROMETER REJECTS...
```

```
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C      BAROM, WIND VECTORS, AND WIND VEL...
   28 FORMAT(2H0 A4, 3X, 3HBAR, 2X, 10(F6.1,1H(, I2,1H)), /  10X, 2HX-,
     1   3X, 10(I4, 1X, 1H(, I2, 1H), 1X), /  10X, 2HY-, 3X, 10(I4, 1X,
     2   1H(, I2, 1H), 1X), /  9X, 3HVEL, 3X, 10(I4, 1X, 1H(, I2, 1H),
     3   1X)    )
C      TWO DEGREE TEMPS...
   29 FORMAT(2H0 A4, 13X,  5( 5X,F4.1,1X, 1H(, I3, 1H), F5.1))
C      FIVE DEGREE FORMAT...
   30 FORMAT(2H0 A4,28X,8HSEA TEMP12X, F4.1, 1X, 1H(, I3, 1H), 40X,
     1   F4.1, 1X, 1H(, I3, 1H)/34X,8HAIR TEMP 12X,F4.1,1X,1H(,I3,1H),
     2 40X,F4.1,1X,1H(,I3,1H),/ 36X,6HDEW PT,12X,F4.1,1X,1H(,I3,1H),40X,
     3  F4.1,1X,1H(,I3,1H)/     37X,5HBAROM,10X,F6.1,1X,1H(,I3,1H),38X,
     4   F6.1,1X,1H(,I3,1H)/                        40X, 2HX-, 12X, I4, 1X, 1
     5   H(, I3, 1H), 40X, I4, 1X, 1H(, I3, 1H), / 40X, 2HY-, 12X, I4, 1
     6   X, 1H(, I3, 1H), 40X, I4, 1X, 1H(, I3, 1H), / 39X, 3HVEL, 10X,
     7   F6.0, 1X, 1H(, I3, 1H), 38X, F6.0, 1X, 1H(, I3, 1H), / 36X, 6HC
     8LOUDS,12X,F4.2,1X,1H(,I3,1H),40X,F4.2,1X,1H(,I3,1H))
C      TITLE PAGE FORMAT...
   32 FORMAT(1H1//42X,36H U.S. BUREAU OF COMMERCIAL FISHERIES   /,
     1   49X,22H BIOLOGICAL LABORATORY   /,
     2   51X,18H SAN DIEGO, CALIF.     ////,
     3   42X,36H MARINE WEATHER OBSERVATION SUMMARY      /,
     4   56X, 8H FOR THE    /,
     5   53X,14H PACIFIC OCEAN      //,
     6   51X,18H FOR THE MONTH OF    /,53X,A8,2H, ,I4,10(/),
     7   42X,16H DATE OF RUN...  ,A8,1X,I2,2H, ,I4,  7(/)   )
   33 FORMAT(A8,1X,I2,2X,I4,3X,3A8)
C      DECODE FORMAT...
   35 FORMAT(I8)
   37 FORMAT(12A4)
   40 FORMAT(1H0,23X,5HTABLE,F6.3,62H--SEA SURFACE TEMPERATURES (DEGREES
     1 FAHRENHEIT) WITH NUMBER OF / 24X,56HOBSERVATIONS BY ONE-DEGREE QU
     2ADRANGLES FOR THE MONTH OF ,A8,2H, ,I4,1H. /)
   41 FORMAT(1H0,26X,5HTABLE,F6.3,56H--SEA SURFACE TEMPERATURES (DEGREES
     1 FAHRENHEIT) REJECTED /27X,52HREADINGS BY ONE-DEGREE QUADRANGLES F
     2OR THE MONTH OF  ,A8,2H, ,I4,1H. /)
   42 FORMAT(1H0,9X,5HTABLE,F6.3,89H--BAROMETRIC PRESSURES (MILLIBARS),
     1X- AND Y-WIND VECTORS (KNOTS), AND AVERAGE WIND SPEED /12X,80H(KNO
     2TS) WITH NUMBER OF OBSERVATIONS BY ONE-DEGREE QUADRANGLES FOR THE
     3MONTH OF  ,A8,2H, ,I4,1H. /)
   43 FORMAT(1H0,28X,5HTABLE,F6.3,52H--BAROMETRIC PRESSURES (MILLIBARS)
     1REJECTED READINGS /30X,44HBY ONE-DEGREE QUADRANGLES FOR THE MONTH
     2OF  ,A8,2H, ,I4,1H. /)
   44 FORMAT(1H0,17X,5HTABLE,F6.3,73H--SEA SURFACE TEMPERATURES (DEGREES
     1 FAHRENHEIT AND CENTIGRADE) AND NUMBER /18X,60HOF OBSERVATIONS BY
     2TWO-DEGREE QUADRANGLES FOR THE MONTH OF  ,A8,2H, ,I4,1H. /)
   45 FORMAT(1H0,9X,5HTABLE,F6.3,91H--SEA SURFACE TEMPERATURES (DEGREES
     1CENTIGRADE), AIR TEMPERATURES (DEGREES CENTIGRADE), DEW /8X,105HPO
     2INT TEMPERATURES (DEGREES CENTIGRADE), BAROMETRIC PRESSURES (MILLI
     3BARS), X- AND Y-WIND VECTORS (KNOTS),   /6X,107HAVERAGE WIND   SPE
     4EDS   (KNOTS), CLOUD COVER (TENTHS OF SKY COVERED), AND HEAT BUDGE
     5T (CALORIES/CENTIMETER-   /10X,86HSQUARED/DAY), WITH NUMBER OF OBS
     6ERVATIONS BY FIVE-DEGREE QUADRANGLES FOR THE MONTH OF   ,A8,2H, ,
     7 I4,1H.   /)
   46 FORMAT(1H1,////,51X,17HTABLE OF CONTENTS/9(/),1X,74HSEA SURFACE TE
     1MPERATURES (DEGREES FAHRENHEIT) WITH NUMBER OF OBSERVATIONS  //1X,
     243HBY ONE-DEGREE QUADRANGLES FOR THE MONTH OF  ,A8,2H, ,I4,1H.,40X
     3,13HTABLES 1.001-,F6.3//////1X,95HBAROMETRIC PRESSURES (MILLIBARS)
     4, X- AND Y-WIND VECTORS (KNOTS), AND AVERAGE WIND SPEED (KNOTS),//
     51X,71HWITH NUMBER OF OBSERVATIONS BY ONE-DEGREE QUADRANGLES FOR TH
     6F MONTH OF  ,A8,2H, ,I4,1H. 12X,13HTABLES 2.001-,F6.3,//////1X,72H
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     7SEA SURFACE TEMPERATURES (DEGREES FAHRENHEIT) AND NUMBER OF OBSERV
     8ATIONS  //1X,43HBY TWO-DEGREE QUADRANGLES FOR THE MONTH OF   ,A8,
     92H, ,I4,1H.  40X,13HTABLES 3.001-  F6.3//////)
  47 FORMAT(45X,24HNUMBER OF OBSERVATIONS  I5/45X,24HNUMBER OF REJECTIO
     1NS     I5/45X,24HSUMMARIZED OBSERVATIONS I5////////
     2   42X,33H PROGRAMMED BY... MARVIN W. CLINE  //
     3   42X, 18H PROCESSED BY....     3A8)
  48 FORMAT(                                                  14X, 2(
     1   11X, 39HQ(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H) ), / 14X,2(11X,
     2   F4.0, 3X, F4.0, 3X, F4.0, 3X, F4.0, 3X, F4.0, 3X, F4.0)   )
  50 FORMAT(1X,85HSEA SURFACE TEMPERATURES (DEGREES CENTIGRADE), AIR TE
     1MPERATURES (DEGREES CENTIGRADE), //1X,84HDEW POINT TEMPERATURES (D
     2EGREES CENTIGRADE, BAROMETRIC PRESSURES (MILLIBARS), X- AND //1X,
     383HY-WIND VECTORS (KNOTS), AVERAGE WIND   SPEEDS   (KNOTS), CLOUD
     4COVER (TENTHS OF SKY //1X,76HCOVERED), AND HEAT BUDGET (CALORIES/C
     5ENTIMETER-SQUARED/DAY), WITH NUMBER OF  //1X,57HOBSERVATIONS BY FI
     6VE-DEGREE QUADRANGLES FOR THE MONTH OF   ,A8,2H, ,I4,1H. ,
     7   26X,13HTABLES 4.001- F6.3/1H1)
  51 FORMAT(1H0,29X,15HLATITUDE RANGE ,A4,1H-,A4,12X,16HLONGITUDE RANGE
     1 ,A4,1H-,A4/ /)
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C      CONSTANTS...
       A=15.0
       B=15.0
       DO 69 I=1,6
  69 TABLE(I)=I
       JK=10
       JL=20
       JM=30
       JJJJ=0
       KKKK=0
       I3=10**3
       I4=10**4
       I5=10**5
       I6=10**6
       I7=10**7
       I8=10**8
       I9=10**9
       I10=10**10
       I11=10**11
       I12=10**12
       I13=10**13
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C      READ IN PERM. TABLES...
       READ 10, XK1, XK2
       READ 11,  HEAD, AHEAD, HEAD2, AHEAD2
       READ 37, HEAD5, AHEAD5
       READ 12, HEAT, REFLECT
       READ 13, FS
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C      READ HEADER CARD AND SET UP LIMITS...
C       PULL PRECEDING CARD   REPLACE WITHOUT STATEMENT NUMBER
 6969 READ INPUT TAPE 10,16, LIMLATN,  DIRN, LIMLATS,  DIRS, LIMLONGW,
     1   DIRW, LIMLONGE,  DIRE, NO,AMONTH, IYEAR, MARKT, MARKB
       READ INPUT TAPE 10, 33, XDATE, IDAY, JYEAR, XNAME
C      READ MONTHLY TABLES...
       READ INPUT TAPE 10,14, MEANSEA
       READ INPUT TAPE 10,15, MEANBAR
       IF (LIMLATN-6) 1000,1000,1006
 1000 IF (DIRN-1HN) 1002,1001,1002
 1001 LIMLATN=60-LIMLATN*10
       GO TO 1007
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 1002 IF (DIRN-1HS) 1004,1003,1004
 1003 LIMLATN=60+LIMLATN*10
      GO TO 1007
 1004 IF (DIRN-1H ) 1006,1005,1006
 1005 IF (LIMLATN) 1006,1001,1006
 1006 LIMLATN=0
 1007 IF (LIMLATS-6) 1107,1107,1013
 1107 IF (DIRS-1HS) 1009,1008,1009
 1008 LIMLATS=60+LIMLATS*10
      GO TO 1014
 1009 IF (DIRS-1HN) 1011,1010,1011
 1010 LIMLATS=60-LIMLATS*10
      GO TO 1014
 1011 IF (DIRS-1H ) 1013,1012,1013
 1012 IF (LIMLATS) 1013,1010,1013
 1013 LIMLATS=120
 1014 IF (LIMLATS-LIMLATN) 1015,1015,1016
 1015 LIMLATN=0
      LIMLATS=120
 1016 IF (LIMLONGW) 1022,1116,1115
 1115 IF (LIMLONGW-18) 1116,1116,1022
 1116 IF (DIRW-1HW) 1018,1017,1018
 1017 LIMLONGW=LIMLONGW*10
      GO TO 1023
 1018 IF (DIRW-1HE) 1020,1019,1020
 1019 LIMLONGW=360-LIMLONGW*10
      GO TO 1023
 1020 IF (DIRW-1H ) 1022,1021,1022
 1021 IF (LIMLONGW-18) 1022,1017,1022
 1022 LIMLONGW=70
 1023 IF (LIMLONGE-18) 1123,1123,1029
 1123 IF (DIRE-1HE) 1025,1024,1025
 1024 LIMLONGE=360-LIMLONGE*10
      GO TO 1030
 1025 IF (DIRE-1HW) 1027,1026,1027
 1026 LIMLONGE=LIMLONGE*10
      GO TO 1030
 1027 IF (DIRE-1H ) 1029,1028,1029
 1028 IF (LIMLONGE-18) 1029,1026,1029
 1029 LIMLONGE=180
 1030 IF (LIMLONGW-LIMLONGE) 1032,1031,1031
 1031 LIMLONGW=70
      LIMLONGE=180
 1032 LONGCHK=LIMLONGW+10
      LATN1=LIMLATN+1
      LATS1=LIMLATS
      LATN2=(LATN1+1)/2
      LATS2=(LATS1+1)/2
      LATN5=(LATN1+4)/5
      LATS5=(LATS1+4)/5
      IF (NO) 1033,1033,2033
 2033 IF (NO-12) 1034,1034,1033
 1033 NO=12
 1034 CONTINUE
      ICOUNT=0
      ASSIGN 6000 TO NOT
 6000 IF (UNIT, JK) 6000,6001,7003,7000
 6001 BUFFER IN (JK,0) (IBUFFER1(1),IBUFFER1(15))
C * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     ZERO ARRAYS...
 1035 CALL ZERO (16920, ISEATEMP)
      ASSIGN 6002 TO NOT
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C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C       DECODE DATA INTO ALPHANUMERIC AND NUMERIC FORMS, START PROGRAM...
  103 ICOUNT=0
 6002 IF (UNIT, JK) 6002, 104,7003,7000
  104 DECODE ( 80, 17, IBUFFER1)  ALPHA
      DECODE ( 64, 18, IBUFFER1) BLANK
  105 BUFFER IN (JK,0) (IBUFFER1(1),IBUFFER1(15))
C       TESTS FOR XS AND BLANKS  ALPHA AND NUMERIC
  106 IF (ALPHA(19)-5H*****) 107,204,107
  107 I=0
 5107 I=I+1
      IF (BLANK(I)-1H ) 103,108,103
  108 IF (I-10) 5107,5108,5108
 5108 IF (DOLT(ALPHA(1),1)) 103,110,103
  110 DECODE (8, 35, ALPHA(1))  IOCTANT
      IOCTANT=IOCTANT/I7
      IF (DOLT(ALPHA(2),2)) 103,112,103
  112 DECODE (8, 35, ALPHA(2))  ILAT
      ILAT=ILAT/I6
      IF (DOLT(ALPHA(3),2)) 103,114,103
  114 DECODE (8, 35, ALPHA(3))  ILONG
      ILONG=ILONG/I6
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C       COMPUTATION OF LONG AND LAT SUBSCRIPTS FOR 1 DEG, 2 DEG AND 5 DEG
C       ARRAYS...
  117 IDUMMY=IOCTANT+1
      GO TO (118,118,118,118,103,119,119,119,119,103), IDUMMY
  118 LAT=60-ILAT
      GO TO 600
  119 LAT=61+ILAT
  600 IF (LAT-LIMLATN) 103,103,601
  601 IF (LAT-LIMLATS) 122,103,103
  122 MLAT=(LAT+4)/5
      KLAT=(LAT+1)/2
  123 GO TO (125,126,129,131,103,125,126,129,131,103), IDUMMY
  126 IF (ILONG-80) 127,103,125
  127 ILONG=ILONG+100
  125 LONG=10-ILONG+ILONG/10*10
      ILONG=ILONG+1
  124 MLONG=(LONG+4)/5
      KLONG=(LONG+1)/2
      GO TO 135
  129 IF (ILONG-80) 130,103,131
  130 ILONG=ILONG+100
  131 LONG=1+ILONG-ILONG/10*10
      ILONG=360-ILONG
      GO TO 124
  135 JLONG=(ILONG+4)/5
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C       IS CARD IN LIMITS...
      IF (MEANSEA(JLONG,MLAT)) 103,999,999
  999 IF (LONGCHK-ILONG) 103,136,136
  136 IF (ILONG-LONGCHK+10) 103,103,137
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C       ZERO INDICATOR SEARCH...
  137 I=7
 5137 I=I+3
      IF (ALPHA(I)-1H0) 138,139,138
  138 IF (I-16) 5137,175,175
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C       SEA TEMPERATURE SUBROUTINE...
  139 IF (DOLT(ALPHA(9),2)) 175,141,175
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  141 DECODE (8, 35, ALPHA(9))  ITEMP
      ITEMP=ITEMP/16
      IF (DOLT(ALPHA(I+1),2)) 175,142,175
  142 DECODE (8, 35, ALPHA(I+1))   IDIFF
      IDIFF=IDIFF/16
C     SUB-ZERO AND OTHER JUNK SUBROUTINE...
      IF (LONGCHK-180) 9550,9550,9500
 9500 IF (NO-3) 9510,9510,143
 9510 IF (LAT-20) 9530,9530,9520
 9520 IF (LAT-101) 143,9530,9530
 9530 IF (ITEMP-50) 143,143,9540
 9540 ITEMP=50-ITEMP
      GO TO 143
 9550 IF (NO-3) 9560,9560,8001
 9560 IF (LAT-20) 9580,9580,9570
 9570 IF (LAT-101) 8001,9580,9580
 9580 IF (ITEMP-50) 8001,8001,9590
 9590 IF (ITEMP-79) 9600,9600,9610
 9600 ITEMP=50-ITEMP
      GO TO 143
 9610 ITEMP=ITEMP-100
      GO TO 147
 8001 IF (NO-3) 9710,9710,9700
 9700 IF (NO-12) 9730,9710,9730
 9710 IF (LAT-40) 9720,9720,9730
 9720 IF (ITEMP-30) 143,147,147
 9730 IF (ITEMP-36) 143,147,147
  143 IF (IDIFF-50) 145,144,144
  144 JTEMP=ITEMP*10+(IDIFF-50)*10/2
      XDUMMY=IDIFF
      DIFF(MLONG,MLAT)=DIFF(MLONG,MLAT)+(XDUMMY-50.0)/2.0
      GO TO 146
  145 JTEMP=ITEMP*10-IDIFF*10/2
      XDUMMY=IDIFF
      DIFF(MLONG,MLAT)=DIFF(MLONG,MLAT)-XDUMMY/2.0
C     STATEMENT 146 CONVERTS TEMP FROM C TO F...
  146 JTEMP=(JTEMP*180)/100+320
      GO TO 150
  147 IF (IDIFF-50) 148,149,149
  148 JTEMP=(ITEMP-IDIFF)*10
      XDUMMY=IDIFF
      DIFF(MLONG,MLAT)=DIFF(MLONG,MLAT)-XDUMMY/1.8
      GO TO 150
  149 JTEMP=(ITEMP+IDIFF-50)*10
      XDUMMY=IDIFF
      DIFF(MLONG,MLAT)=DIFF(MLONG,MLAT)+(XDUMMY-50.0)/1.8
  150 COUNT(MLONG,MLAT)=COUNT(MLONG,MLAT)+1.0
C     COMPARE WITH MEAN TEMP...
      N=LAT-LAT/10*10
      IF (N) 103,151,152
  151 N=10
  152 IFINK=MEANSEA(JLONG,MLAT)
      LIMIT=IFINK/1000
      IF (IFINK) 103,160,153
  153 IF (N-3) 154,161,162
  154 NN=3
  155 NNN=-1
  157 IF (MLAT-1)  103,161,158
  163 NN=8
      NNN=1
  156 IF (MLAT-24) 158,161,103
  158 IF (MEANSEA(JLONG,MLAT+NNN)) 161,161,5158
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5158 IMEAN=IFINK-LIMIT*1000-(IFINK-LIMIT*1000-MEANSEA(JLONG,MLAT+NNN)+
    1  MEANSEA(JLONG,MLAT+NNN)/1000*1000)*XABSF(NN-N)/5
 159 IF (XABSF(JTEMP-IMEAN)-LIMIT*10) 160,160,167
 160 ISEATEMP(LONG,LAT)=JTEMP+ISEATEMP(LONG,LAT)
     ISEA(LONG,LAT)=ISEA(LONG,LAT)+1
     JSEATEMP(KLONG,KLAT)=JSEATEMP(KLONG,KLAT)+JTEMP
     JSEA(KLONG,KLAT)=JSEA(KLONG,KLAT)+1
     KSEATEMP(MLONG,MLAT)=KSEATEMP(MLONG,MLAT)+(JTEMP-320)*100/180
     KSEA(MLONG,MLAT)=KSEA(MLONG,MLAT)+1
     GO TO 170
 161 IMEAN=IFINK-LIMIT*1000
     GO TO 159
 162 IF (N-8) 164,161,163
 164 IF (N-6) 165,166,166
 165 NN=3
     NNN=1
     GO TO 158
 166 NN=8
     NNN=-1
     GO TO 158
C    REJECT ARRAY FILL...
 167 IF (JTEMP) 103,9167,9167
9167 IF (MARKT) 1167,103,1167
1167 DO 168 J=1,3
     IF (IREJT(LONG,LAT)-J) 169,168,168
 168 CONTINUE
     JJJJ=JJJJ+1
     GO TO 103
 169 ITEMPREJ(LONG,LAT)=ITEMPREJ(LONG,LAT)+JTEMP/10*10**((J-1)*3)
     IREJT(LONG,LAT)=IREJT(LONG,LAT)+1
     JJJJ=JJJJ+1
     GO TO 103
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C    DEW POINT SUBROUTINE...
 170 IF (DOLT(ALPHA(I+2),2)) 175,171,175
 171 DECODE (8, 35, ALPHA(I+2))  IDEWPT
     IDEWPT=IDEWPT/I5
8002 IF (IDEWPT-990)5170,103,103
5170 IF (ITEMP-36) 5171,5172,5172
5171 IDEWPT=IDEWPT*180/100+320
5172 IF (XABSF(IDEWPT-JTEMP)-200) 172,172,175
 172 JDEWPT(MLONG,MLAT)=JDEWPT(MLONG,MLAT)+IDEWPT
     JDEW(MLONG,MLAT)=JDEW(MLONG,MLAT)+1
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C    CLOUD COVER SUBROUTINE...
 175 IF (DOLT(ALPHA(4),1)) 181,177,181
 177 DECODE (8, 35, ALPHA(4))  ICLOUD
     ICLOUD=ICLOUD/I7
8003 IF (ICLOUD-9) 180,178,181
 178 IF (DOLT(ALPHA(7),2)) 181,800,181
 800 DECODE (8, 35, ALPHA(7))  IVIS
     IVIS=IVIS/I6
     IF (IVIS-90) 2000,2001,179
 179 IF (IVIS-93) 2001,2001,181
2000 IF (IVIS-5)  2001,2001,181
2001 ICLOUD=8
 180 JCLOUD(MLONG,MLAT)=JCLOUD(MLONG,MLAT)+(ICLOUD*100/8)
     JCLO(MLONG,MLAT)=JCLO(MLONG,MLAT)+1
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C    BAROMETER SUBROUTINE...
 181 IF (DOLT(ALPHA(8),3)) 103,183,103
 183 DECODE (8, 35, ALPHA(8))  IPRESS
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```
      IPRESS=IPRESS/15
 8004 IF (IPRESS-500) 184,103,185
  184 IPRESS=IPRESS+10000
      GO TO 186
  185 IPRESS=IPRESS+9000
  186 IFINK=MEANBAR(JLONG,MLAT)
      LIMIT=IFINK/10000
      IF (IFINK) 103,189,6500
 6500 N=LAT-LAT/10*10
      IF (N) 103,700,701
  700 N=10
  701 IF (N-3) 702,6700,704
  702 NN=3
      NNN=-1
      GO TO 6501
  704 IF (N-8) 706,6700,705
  705 NN=8
      NNN=1
      GO TO 703
  706 IF (N-6) 707,708,708
  707 NN=3
      NNN=1
      GO TO 187
  708 NN=8
      NNN=-1
      GO TO 187
  703 IF (MLAT-24) 187,6700,103
 6501 IF (MLAT-1) 103,6700,187
 6700 IMEAN=IFINK-LIMIT*10000
      GO TO 188
  187 IF (MEANBAR(JLONG,MLAT+NNN)) 6700,6700,5187
 5187 IMEAN=IFINK-LIMIT*10000-(IFINK-LIMIT*10000-MEANBAR(JLONG,MLAT+NNN)
     1 +MEANBAR(JLONG,MLAT+NNN)/10000*10000)*XABSF(NN-N)/5
  188 IF (XABSF(IPRESS-IMEAN)-LIMIT*10) 189,189,190
  189 IBAROM(LONG,LAT)=IBAROM(LONG,LAT)+IPRESS
      IBAR(LONG,LAT)=IBAR(LONG,LAT)+1
      KBAROM(MLONG,MLAT)=KBAROM(MLONG,MLAT)+IPRESS
      KBAR(MLONG,MLAT)=KBAR(MLONG,MLAT)+1
      GO TO 193
C     REJECT ARRAY FILL...
  190 IF (MARKB) 1190,103,1190
 1190 DO 191 J=1,2
      IF (IREJB(LONG,LAT)-J) 192,191,191
  191 CONTINUE
      JJJJ=JJJJ+1
      GO TO 103
  192 IBAROREJ(LONG,LAT)=IBAROREJ(LONG,LAT)+IPRESS/10*10**((J-1)*6)
      IREJB(LONG,LAT)=IREJB(LONG,LAT)+1
      JJJJ=JJJJ+1
      GO TO 103
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     WIND SUBROUTINE...
  193 IF (DOLT(ALPHA(6),2)) 103,195,103
  195 DECODE (8, 35, ALPHA(6))  IVEL
      IVEL=IVEL/16
  196 IF (DOLT(ALPHA(5),2)) 103,198,103
  198 DECODE (8, 35, ALPHA(5))  IDIR
      IDIR=IDIR/16
      IF (IDIR) 103,197,199
  197 IVEL=0
      GO TO 202
  199 IF (IDIR-51) 202,200,200
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  200 IF (IDIR-99) 201,103,103
  201 IDIR=IDIR-50
      IVEL=IVEL+100
  202 IDIR=IDIR*10
      VEL=IVEL
      XDUMMY=IDIR
      IX=SINF(XDUMMY*0.0174)*VEL*(-1.0)
      IY=COSF(XDUMMY*0.0174)*VEL*(-1.0)
      KWINDIRX(MLONG,MLAT)=KWINDIRX(MLONG,MLAT)+IX
      KWINDIRY(MLONG,MLAT)=KWINDIRY(MLONG,MLAT)+IY
      KWIND(MLONG,MLAT)=KWIND(MLONG,MLAT)+1
      IWINDIRX(LONG,LAT)=IWINDIRX(LONG,LAT)+IX
      IWINDIRY(LONG,LAT)=IWINDIRY(LONG,LAT)+IY
      IWIND(LONG,LAT)=IWIND(LONG,LAT)+1
  203 IWINDVEL(LONG,LAT)=IWINDVEL(LONG,LAT)+IVEL
      IWINDV(LONG,LAT)=IWINDV(LONG,LAT)+1
      KWINDVEL(MLONG,MLAT)=KWINDVEL(MLONG,MLAT)+IVEL
      KWINDV(MLONG,MLAT)=KWINDV(MLONG,MLAT)+1
      GO TO 103
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     START OF HEAT EQUATIONS AND OUTPUT SUBROUTINES
C     ONE DEGREE OUTPUT (TEMPS ONLY) ...
C     NOTE... TWO REELS ARE REQUIRED FOR OUTPUT IF IT IS INDICATED ON THE
C     HEADER CARD THAT REJECTS ARE DESIRED.
  204 IF (ALPHA(20)-5H*****) 5204,5247,5204
 5204 IF ((TABLE(1)-1.0)*39.0+(TABLE(2)-2.0)*57.0+(TABLE(3)-3.0)*39.0+
     1  (TABLE(4)-4.0)*71.0-A) 5206,5205,5205
 5205 CALL CHANGE (JL,A)
 5206 IF ((TABLE(5)-5.0)*39.0+(TABLE(6)-6.0)*39.0-B) 5208,5207,5207
 5207 CALL CHANGE (JM,B)
 5208 M=LONGCHK-9
      TABLE(1)=TABLE(1)+0.001
      TABLE(5)=TABLE(5)+0.001
      LINE=0
 4000 WRITE OUTPUT TAPE JL, 19,
      WRITE OUTPUT TAPE JL, 40, TABLE(1), AMONTH, IYEAR
      WRITE OUTPUT TAPE JL, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
     1  AHEAD(LONGCHK)
      WRITE OUTPUT TAPE JL, 21, (AHEAD(I), I=M,LONGCHK)
 4002 IF (MARKT) 205,206,205
  205 WRITE OUTPUT TAPE JM, 19,
      WRITE OUTPUT TAPE JM, 41, TABLE(5), AMONTH, IYEAR
      WRITE OUTPUT TAPE JM, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
     1  AHEAD(LONGCHK)
      WRITE OUTPUT TAPE JM, 21, (AHEAD(I), I=M,LONGCHK)
  206 DO 214 J=LATN1, LATS1
      DO 212 I=1,10
      IC1(I)=ISEA(I,J)
      IF (IC1(I)) 210,210,207
  207 IC2(I)=ISEATEMP(I,J)/IC1(I)
      IF (IC2(I)-IC2(I)/10*10-5) 208,209,209
  208 XIC2(I)=IC2(I)/10
      GO TO 5000
  209 XIC2(I)=(IC2(I)+5)/10
      GO TO 5000
  210 XIC2(I)=0.0
 5000 IF (MARKT) 211,212,211
  211 IREJ(I*3-2)=ITEMPREJ(I,J)/I6
      IREJ(I*3-1)=(ITEMPREJ(I,J)-IREJ(I*3-2)* I6   )/I3
      IREJ(I*3)=ITEMPREJ(I,J)-IREJ(I*3-2)* I6   -IREJ(I*3-1)*I3
      XREJ(I*3-2)=IREJ(I*3-2)
      XREJ(I*3-1)=IREJ(I*3-1)
```

```
      XREJ(I*3)=IREJ(I*3)
  212 CONTINUE
      LINE=LINE+1
      IF (LINE-30) 4005,4005,9000
 9000 TABLE(1)=TABLE(1)+0.001
      LINE=1
 9001 WRITE OUTPUT TAPE JL, 19,
      WRITE OUTPUT TAPE JL, 40, TABLE(1), AMONTH, IYEAR
      WRITE OUTPUT TAPE JL, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
     1  AHEAD(LONGCHK)
      WRITE OUTPUT TAPE JL, 21, (AHEAD(I), I=M,LONGCHK)
 9003 IF (MARKT) 9004,4005,9004
 9004 TABLE(5)=TABLE(5)+0.001
 9005 WRITE OUTPUT TAPE JM, 19,
      WRITE OUTPUT TAPE JM, 41, TABLE(5), AMONTH, IYEAR
      WRITE OUTPUT TAPE JM, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
     1  AHEAD(LONGCHK)
      WRITE OUTPUT TAPE JM, 21, (AHEAD(I),I=M, LONGCHK)
 4005 WRITE OUTPUT TAPE JL,25,  HEAD(J), (XIC2(I),IC1(I), I=1,10)
 4007 IF (MARKT) 213,214,213
  213 WRITE OUTPUT TAPE JM,26,  HEAD(J),XREJ
  214 CONTINUE
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C      REMAINDER OF ONE DEGREE OUTPUT...
      TABLE(2)=TABLE(2)+0.001
      TABLE(6)=TABLE(6)+0.001
      LINE=0
      JLINE=0
 2215 WRITE OUTPUT TAPE JL, 19,
      WRITE OUTPUT TAPE JL, 42, TABLE(2), AMONTH, IYEAR
      WRITE OUTPUT TAPE JL, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
     1  AHEAD(LONGCHK)
      WRITE OUTPUT TAPE JL, 21, (AHEAD(I), I=M, LONGCHK)
 4215 IF (MARKB) 215,216,215
  215 WRITE OUTPUT TAPE JM, 19,
      WRITE OUTPUT TAPE JM, 43, TABLE(6), AMONTH, IYEAR
      WRITE OUTPUT TAPE JM, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
     1  AHEAD(LONGCHK)
      WRITE OUTPUT TAPE JM, 21, (AHEAD(I), I=M, LONGCHK)
  216 DO 226 J=LATN1, LATS1
      DO 224 I=1,10
      IC2(I)=IBAR(I,J)
      IF (IC2(I)) 218,218,217
  217 BAROM(I)=IBAROM(I,J)/IC2(I)
      BAROM(I)=BAROM(I)/10.0
      GO TO 5001
  218 BAROM(I)=0.0
 5001 IC3(I)=IWIND(I,J)
      IF (IC3(I)) 220,220,219
  219 IC5(I)=IWINDIRX(I,J)/IC3(I)
      IC4(I)=IWINDIRY(I,J)/IC3(I)
      GO TO 5002
  220 IC4(I)=0
      IC5(I)=0
 5002 IC6(I)=IWINDV(I,J)
      IF (IC6(I)) 222,222,221
  221 IWINDVEL(I,J)=IWINDVEL(I,J)/IC6(I)
      GO TO 5003
  222 IWINDVEL(I,J)=0
 5003 IF (MARKB) 223,224,223
  223 IREJ(I*2-1)=IBAROREJ(I,J)/I6
      IREJ(I*2)=IBAROREJ(I,J)-IREJ(I*2-1)*I6
```

```
      XREJ(I*2-1)=IREJ(I*2-1)
      XREJ(I*2)=IREJ(I*2)
  224 CONTINUE
      LINE =LINE+1
      JLINE=JLINE+1
      IF (LINE-12) 9010,9010,9007
 9007 TABLE(2)=TABLE(2)+0.001
      LINE=1
 9008 WRITE OUTPUT TAPE JL, 19,
      WRITE OUTPUT TAPE JL, 42, TABLE(2), AMONTH, IYEAR
      WRITE OUTPUT TAPE JL, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
     1  AHEAD(LONGCHK)
      WRITE OUTPUT TAPE JL, 21, (AHEAD(I), I=M, LONGCHK)
 9010 IF (MARKB) 9011,4011,9011
 9011 IF (JLINE-30) 4011,4011,9012
 9012 JLINE=1
      TABLE(6)=TABLE(6)+0.001
      WRITE OUTPUT TAPE JM, 19,
      WRITE OUTPUT TAPE JM, 43, TABLE(6), AMONTH, IYEAR
      WRITE OUTPUT TAPE JM, 20, HEAD(LATN1), HEAD(LATS1), AHEAD(M),
     1  AHEAD(LONGCHK)
      WRITE OUTPUT TAPE JM, 21, (AHEAD(I), I=M, LONGCHK)
 4011 WRITE OUTPUT TAPE JL,28, HEAD(J), (BAROM(I),IC2(I), I=1,10),
     1    (IC5(I),IC3(I), I=1,10), (IC4(I),IC3(I), I=1,10),
     2  ((IWINDVEL(I,L), IC6(I), I=1,10), L=J,J)
 4013 IF (MARKB) 225,226,225
  225 WRITE OUTPUT TAPE JM,27,  HEAD(J), (XREJ(L),L=1,20)
  226 CONTINUE
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     TWO DEGREE OUTPUT LOOPS...
      TABLE(3)=TABLE(3)+0.001
      LINE=0
 2227 M=LONGCHK/2
      L=M-4
 4015 WRITE OUTPUT TAPE JL, 19,
      WRITE OUTPUT TAPE JL, 44, TABLE(3), AMONTH, IYEAR
      WRITE OUTPUT TAPE JL, 20, HEAD2(LATN2), HEAD2(LATS2),AHEAD2(L),
     1  AHEAD2(M)
      WRITE OUTPUT TAPE JL, 22, (AHEAD2(I), I=L,M)
 4017 DO 229 J=LATN2, LATS2
      DO 5004 I=1,5
      IC1(I)=JSFA(I,J)
      IF (IC1(I)) 228,228,227
  227 IC2(I)=JSFATEMP(I,J)/IC1(I)
      XIC2(I)=IC2(I)
      XIC2(I)=XIC2(I)/10.0
      BAROM(I)=(XIC2(I)-32.0)/1.8
      GO TO 5004
  228 XIC2(I)=0.0
      BAROM(I)=0.0
 5004 CONTINUE
      LINE=LINE+1
      IF (LINE-32) 5229,5229,9014
 9014 TABLE(3)=TABLE(3)+0.001
      LINE=1
 9015 WRITE OUTPUT TAPE JL, 19,
      WRITE OUTPUT TAPE JL, 44, TABLE(3), AMONTH, IYEAR
      WRITE OUTPUT TAPE JL, 20, HEAD2(LATN2), HEAD2(LATS2),AHEAD2(L),
     1  AHEAD2(M)
      WRITE OUTPUT TAPE JL, 22, (AHEAD2(I), I=L,M)
 5229 WRITE OUTPUT TAPE JL,29, HEAD2( J ),(XIC2(I),IC1(I),BAROM(I),
     1   I=1,5)
```

```
  229 CONTINUE
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     FIVE DEGREE OUTPUT LOOPS...
      TABLE(4)=TABLE(4)+0.001
      LINE=0
 4019 M=LONGCHK/5
      L=M-1
 4020 WRITE OUTPUT TAPE JL, 19,
      WRITE OUTPUT TAPE JL, 45, TABLE(4), AMONTH, IYEAR
      WRITE OUTPUT TAPE JL, 51, HEAD5(LATN5), HEAD5(LATS5),AHEAD5(L),
     1 AHEAD5(M)
      WRITE OUTPUT TAPE JL, 23, (AHEAD5(I), I=L, M)
 4022 DO 246 J=LATN5, LATS5
      DO 245 I=1,2
      ITEST=0
      IC1(I)=KSEA(I,J)
      IF (IC1(I)) 233,233,230
  230 XIC2(I)=KSEATEMP(I,J)/IC1(I)
      XIC2(I)=XIC2(I)/10.0
      GO TO 5005
  233 XIC2(I)=0.0
      ITEST=1
 5005 IC3(I)=JDEW(I,J)
      IF (IC3(I)) 235,235,234
  234 XIC4(I)=JDEWPT(I,J)/IC3(I)
      XIC4(I)=(XIC4(I)-320.0)/18.0
      GO TO 5006
  235 XIC4(I)=0.0
      ITEST=1
 5006 IC5(I)=KWIND(I,J)
      IF (IC5(I)) 237,237,236
  236 IC6(I)=KWINDIRX(I,J)/IC5(I)
      IC7(I)=KWINDIRY(I,J)/IC5(I)
      GO TO 5007
  237 IC6(I)=0
      IC7(I)=0
      ITEST=1
 5007 IC8(I)=KWINDV(I,J)
      IF (IC8(I)) 239,239,238
  238 XIC9(I)=KWINDVEL(I,J)/IC8(I)
      GO TO 5008
  239 XIC9(I)=0.0
      ITEST=1
 5008 IC10(I)=JCLO(I,J)
      IF (IC10(I)) 241,241,240
  240 CLOUD(I)=JCLOUD(I,J)/IC10(I)
      CLOUD(I)=CLOUD(I)/100.0
      GO TO 260
  241 CLOUD(I)=0.0
      ITEST=1
  260 IC2(I)=KBAR(I,J)
      IF (IC2(I)) 262,262,261
  261 BAROM(I)=KBAROM(I,J)/IC2(I)
      BAROM(I)=BAROM(I)/10.0
      GO TO 5009
  262 BAROM(I)=0.0
 5009 IF (COUNT(I,J)) 5011,5011,5010
 5010 DIFF(I,J)=DIFF(I,J)/COUNT(I,J)
      GO TO 5012
 5011 DIFF(I,J)=0.0
      ITEST=1
 5012 IF (XINTF(COUNT(I,J))+IC1(I)) 290,290,291
```

```
  291 AIRTEMP(I)=XIC2(I)-DIFF(I,J)
      GO TO 292
  290 AIRTEMP(I)=0.0
  292 KKKK=KKKK+XMAX0F(IC1(I),IC3(I),IC5(I),IC8(I),IC10(I),IC2(I))
      IF (ITEST) 5014,5014,5013
 5013 QR(I)=0.0
      QI(I)=0.0
      QE(I)=0.0
      QB(I)=0.0
      QH(I)=0.0
      GO TO 245
 5014 IF (XMIN0F(IC1(I),IC3(I),IC8(I),IC10(I))-5) 5013,5015,5015
 5015 K=XIC2(I)+1.0
      X=K-1
      L=(XIC2(I)-X     )*10.0+1.0
      M=XIC4(I)+1.0
      X=M-1
      N=(XIC4(I)-X)*10.0+1.0
      X=ES(L,K)-ES(N,M)
      QB(I)=(1.14E-07)*(XIC2(I)+273.0)**4*(0.39-0.050*ES(N,M)**0.5)*
     1  (1.0-XK2(J)*CLOUD(I)**2)+(4.56E-07)*(XIC2(I)+273.0)**3*DIFF(I,J)
      QB(I)=-QB(I)
      QI(I)=HEAT(NO,J)*(1.0-XK1(J)*CLOUD(I)-0.38*CLOUD(I)**2)
      QR(I)=QI(I)*REFLECT(NO,J)*(-1.0)
      QE(I)=2.41*XIC9(I)*X*(-1.0)
  243 QH(I)=-1.58*DIFF(I,J)*XIC9(I)
  245 QT(I)=QI(I)+QR(I)+QB(I)+QE(I)+QH(I)
      LINE=LINE+1
      IF (LINE-6) 5246,5246,9017
 9017 TABLE(4)=TABLE(4)+0.001
      LINE=1
 9018 WRITE OUTPUT TAPE JL, 19,
      WRITE OUTPUT TAPE JL, 45, TABLE(4), AMONTH, IYEAR
      M=LONGCHK/5
      L=M-1
      WRITE OUTPUT TAPE JL, 51, HEAD5(LATN5), HEAD5(LATS5),AHEAD5(L),
     1  AHEAD5(M)
      WRITE OUTPUT TAPE JL, 23, (AHEAD5(I), I=L, M)
 5246 WRITE OUTPUT TAPE JL,30, HEAD5( J ),(XIC2(L),IC1(L),L=1,2),
     1    (AIRTEMP(L), IC1(L), L=1,2), (XIC4(L),IC3(L),L=1,2),
     2(BAROM(L),IC2(L),L=1,2), (IC6(L),IC5(L),L=1,2),(IC7(L),IC5(L),
     3   L=1,2),(XIC9(L),IC8(L),L=1,2),(CLOUD(L),IC10(L),L=1,2)
      WRITE OUTPUT TAPE JL,48,          (QT(L),QI(L),QR(L),QB(L),QE(L),
     1   QH(L),L=1,2)
  246 CONTINUE
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
 5247 IF (ALPHA(21)-5H*****) 6969,248,6969
C     PULL PRECEDING CARD RETURN FOLLOWING CARD
C5247 IF (ALPHA(21)-5H*****) 247,248,247
  247 LONGCHK=LONGCHK+10
      IF (LONGCHK-LIMLONGE)1035,1035,248
C  * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C     BUFFER ERROR ROUTINE
 7000 BACKSPACE JK
      ICOUNT=ICOUNT+1
      IF (ICOUNT-5) 7001,7001,7002
 7001 BUFFER IN (JK,0) (IBUFFER1(1),IBUFFER1(15))
      GO TO NOT, (6000,6002)
 7002 BUFFER IN (JK,0) (IBUFFER1(1),IBUFFER1(15))
      GO TO 7001
 7003 REWIND JK
      JK=JK+1
```

```
      GO TO 7001
 * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
  248 LLLL=KKKK+JJJJ
      WRITE OUTPUT TAPE JL, 32, AMONTH,IYEAR,XDATE,IDAY,JYEAR
  280 WRITE OUTPUT TAPE JL,47,LLLL,JJJJ,KKKK,XNAME
  281 WRITE OUTPUT TAPE JL,46,AMONTH,IYEAR,TABLE(1),AMONTH,IYEAR,
     1   TABLE(2),AMONTH,IYEAR,TABLE(3)
      WRITE OUTPUT TAPE JL,50,AMONTH,IYEAR,TABLE(4)
  271 END FILE JL
      IF (MARKT+MARKB) 249,250,249
  249 END FILE JM
  250 STOP
      END
        IDENT     ZERO
        ENTRY     ZERO
ZERO    RTJ       **
        SAU       Z1
        LLS       48
        SAU       Z2
Z1      LIL    6  **
        ENA       0
Z3      IJP    6  *+1
        SLJ       ZERO
Z2      STA    6  **
        SLJ       Z3
        END
        IDENT     DOLT
        ENTRY     DOLT
DOLT    RTJ       **
        SAU       DOLT8
        LLS       48
        SAU       *+1
        LIL    6  **
        INI    6  -1
DOLT8   LDQ       **
        ENA       0
LOOP    LLS       6
        INA       -12B
        AJP    2  *+2
        AJP    P  DOLT
        ENA       0
        IJP    6  LOOP
        SLJ       DOLT
        END
      SUBROUTINE CHANGE(I,X)
      END FILE I
      REWIND I
      I=I+1
      X=X+15.0
      RETURN
      END
        END       BUCOM
        FINIS
-EXECUTER.
```

APPENDIX B

Tables used in data processing program.

Appendix Table B-1.--Values by month and by latitude of incoming solar radiation with a clear sky. [Adapted from Berliand, 1960.]

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
55N	80	173	355	548	696	761	713	570	398	229	109	58
50N	131	237	411	589	718	774	732	609	450	288	162	105
45N	190	305	464	625	738	784	752	645	497	348	223	162
40N	255	371	514	655	753	789	767	675	539	405	287	227
35N	321	431	559	679	762	789	774	697	578	458	347	290
30N	381	485	597	696	764	784	773	711	612	507	403	349
25N	437	531	627	707	759	774	766	718	641	551	456	405
20N	487	571	652	710	747	759	752	718	663	590	506	458
15N	533	607	672	708	731	737	732	713	681	622	551	507
10N	575	637	688	702	709	708	708	704	693	649	591	553
5N	615	661	700	693	682	674	678	689	700	671	627	597
0N	651	680	706	680	651	637	645	670	700	689	658	637
0S	681	696	706	663	619	599	609	647	693	700	685	675
5S	709	710	699	643	585	558	570	618	679	705	708	710
10S	733	719	687	616	547	513	529	585	659	703	726	740
15S	753	724	670	584	506	467	486	550	635	695	740	764
20S	769	726	650	547	462	419	440	511	571	685	751	784
25S	782	722	625	508	416	372	391	469	539	671	758	802
30S	790	710	595	468	368	323	341	423	540	652	760	816
35S	792	691	559	424	315	269	291	374	502	629	756	826
40S	791	667	520	377	260	211	236	324	461	600	745	831
45S	784	638	477	328	206	153	178	269	416	566	729	828
50S	771	604	430	274	152	100	124	211	367	527	711	818
55S	753	567	380	215	102	54	75	152	310	486	696	808

Appendix Table B-2.--Values by month and by latitude of the percent of incoming solar radiation that is reflected. [Adapted from Budyko, 1956.]

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
55N	.190	.150	.105	.077	.077	.067	.077	.085	.095	.132	.177	.197
50N	.170	.130	.095	.072	.072	.062	.072	.075	.085	.117	.152	.172
45N	.147	.112	.087	.067	.067	.060	.067	.067	.077	.102	.132	.150
40N	.122	.097	.082	.062	.062	.060	.062	.062	.072	.087	.117	.130
35N	.105	.087	.077	.060	.060	.060	.060	.060	.067	.077	.102	.112
30N	.095	.082	.072	.060	.060	.060	.060	.060	.062	.072	.087	.097
25N	.085	.077	.067	.060	.060	.060	.060	.060	.060	.067	.077	.085
20N	.075	.072	.062	.060	.060	.060	.060	.060	.060	.062	.072	.075
15N	.067	.067	.060	.060	.060	.060	.060	.060	.060	.060	.067	.070
10N	.062	.062	.060	.060	.060	.060	.060	.060	.060	.060	.062	.070
5N	.060	.060	.060	.060	.060	.060	.060	.060	.060	.060	.060	.067
0N	.060	.060	.060	.060	.060	.060	.060	.060	.060	.060	.060	.062
0S	.060	.060	.060	.060	.060	.062	.060	.060	.060	.060	.060	.060
5S	.060	.060	.060	.060	.060	.067	.060	.060	.060	.060	.060	.060
10S	.060	.060	.060	.060	.062	.070	.062	.062	.060	.060	.060	.060
15S	.060	.060	.060	.060	.067	.070	.067	.067	.060	.060	.060	.060
20S	.060	.060	.060	.062	.072	.075	.075	.072	.062	.060	.060	.060
25S	.060	.060	.060	.067	.077	.085	.085	.077	.067	.060	.060	.060
30S	.060	.060	.062	.072	.087	.097	.095	.082	.072	.060	.060	.060
35S	.060	.060	.067	.077	.102	.112	.105	.087	.077	.060	.060	.060
40S	.062	.062	.072	.087	.117	.130	.122	.097	.082	.062	.062	.060
45S	.067	.067	.077	.102	.132	.150	.147	.112	.087	.067	.067	.060
50S	.072	.075	.085	.117	.152	.172	.170	.130	.095	.072	.072	.062
55S	.077	.085	.095	.132	.177	.197	.190	.150	.105	.077	.077	.067

Appendix Table B-3.--Values for the constant $\underline{k}$ by latitude used in computation of back radiation. [Adapted from Budyko, 1956.]

55N	50N	45N	40N	35N	30N	25N	20N
0.75	0.73	0.71	0.69	0.67	0.64	0.62	0.60
15N	10N	5N	0N	0S	5S	10S	15S
0.58	0.56	0.53	0.51	0.51	0.53	0.56	0.58
20S	25S	30S	35S	40S	45S	50S	55S
0.60	0.62	0.64	0.67	0.69	0.71	0.73	0.75

Appendix Table B-4.-- Values of saturation vapor pressure over water used in the computation of evaporation. [Adapted from Smithsonian Meteorological Tables, 1958, Table 94, p. 352.]

°C.	0.0 mb.	0.1 mb.	0.2 mb.	0.3 mb.	0.4 mb.	0.5 mb.	0.6 mb.	0.7 mb.	0.8 mb.	0.9 mb.
0.0	6.11	6.15	6.20	6.24	6.29	6.33	6.38	6.43	6.47	6.52
1.0	6.57	6.61	6.66	6.71	6.76	6.81	6.86	6.90	6.95	7.00
2.0	7.05	7.11	7.16	7.21	7.26	7.31	7.36	7.42	7.47	7.52
3.0	7.58	7.63	7.68	7.74	7.79	7.85	7.90	7.96	8.02	8.07
4.0	8.13	8.19	8.24	8.30	8.36	8.42	8.48	8.54	8.60	8.66
5.0	8.72	8.78	8.84	8.90	8.97	9.03	9.09	9.15	9.22	9.28
6.0	9.35	9.41	9.48	9.54	9.61	9.67	9.74	9.81	9.88	9.94
7.0	10.01	10.08	10.15	10.22	10.29	10.36	10.43	10.51	10.58	10.65
8.0	10.72	10.80	10.87	10.94	11.02	11.09	11.17	11.24	11.32	11.40
9.0	11.47	11.55	11.63	11.71	11.79	11.87	11.95	12.03	12.11	12.19
10.0	12.27	12.36	12.44	12.52	12.61	12.69	12.78	12.86	12.95	13.03
11.0	13.12	13.21	13.30	13.38	13.47	13.56	13.65	13.74	13.83	13.93
12.0	14.02	14.11	14.20	14.30	14.39	14.49	14.58	14.68	14.77	14.87
13.0	14.97	15.07	15.17	15.27	15.37	15.47	15.57	15.67	15.77	15.87
14.0	15.98	16.08	16.19	16.29	16.40	16.50	16.61	16.72	16.83	16.94
15.0	17.04	17.15	17.26	17.38	17.49	17.60	17.71	17.83	17.94	18.06
16.0	18.17	18.29	18.41	18.52	18.64	18.76	18.88	19.00	19.12	19.25
17.0	19.37	19.49	19.61	19.74	19.86	19.99	20.12	20.24	20.37	20.50
18.0	20.63	20.76	20.89	21.02	21.16	21.29	21.42	21.56	21.69	21.83
19.0	21.96	22.10	22.24	22.38	22.52	22.66	22.80	22.94	23.09	23.23
20.0	23.37	23.52	23.66	23.81	23.96	24.11	24.26	24.41	24.56	24.71
21.0	24.86	25.01	25.17	25.32	25.48	25.64	25.79	25.95	26.11	26.27
22.0	26.43	26.59	26.75	26.92	27.08	27.25	27.41	27.58	27.75	27.92
23.0	28.09	28.26	28.43	28.60	28.77	28.95	29.12	29.30	29.48	29.65
24.0	29.83	30.01	30.19	30.37	30.56	30.74	30.92	31.11	31.30	31.48
25.0	31.67	31.86	32.05	32.24	32.43	32.63	32.82	33.02	33.21	33.41
26.0	33.61	33.81	34.01	34.21	34.41	34.62	34.82	35.03	35.23	35.44
27.0	35.65	35.86	36.07	36.28	36.50	36.71	36.92	37.14	37.36	37.58
28.0	37.80	38.02	38.24	38.46	38.69	38.91	39.14	39.37	39.59	39.82
29.0	40.06	40.29	40.52	40.76	40.99	41.23	41.47	41.71	41.95	42.19
30.0	42.43	42.67	42.92	43.17	43.41	43.66	43.91	44.17	44.42	44.67
31.0	44.93	45.18	45.44	45.70	45.96	46.22	46.49	46.75	47.02	47.28
32.0	47.55	47.82	48.09	48.36	48.64	48.91	49.19	49.47	49.75	50.03
33.0	50.31	50.59	50.87	51.16	51.45	51.74	52.03	52.32	52.61	52.90
34.0	53.20	53.50	53.80	54.10	54.40	54.70	55.00	55.31	55.62	55.93
35.0	56.24	56.55	56.86	57.18	57.49	57.81	58.13	58.45	58.77	59.10
36.0	59.42	59.75	60.08	60.41	60.74	61.07	61.41	61.74	62.08	62.42
37.0	62.76	63.11	63.45	63.80	64.14	64.49	64.84	65.20	65.55	65.91
38.0	66.26	66.62	66.99	67.35	67.71	68.08	68.45	68.82	69.19	69.56
39.0	69.93	70.31	70.69	71.07	71.45	71.83	72.22	72.61	72.99	73.39

APPENDIX C

Sample page copies of data tabulations produced by the FORTRAN-62 data processing program listed in Appendix A.

Note: Computer printout labels and sign convention in Table 4.022 differ from the text (see p. 17) as follows:

1) $Q(T) = Q_T$,

$Q(I) = Q_I$,

$Q(R) = Q_R$,

$Q(B) = Q_B$,

$Q(E) = Q_E$,

and $Q(H) = Q_H$.

2) $Q(T) = Q(I) + [-Q(R)] + [-Q(B)] + [-Q(E)] + [-Q(H)]$

This equation is equivalent to that given on page 17. The signs in the equation and computer output values have been altered to permit proper notation of the components (heat loss from sea--negative; heat gain by sea--positive).

U.S. BUREAU OF COMMERCIAL FISHERIES
BIOLOGICAL LABORATORY
SAN DIEGO, CALIF.

MARINE WEATHER OBSERVATION SUMMARY
FOR THE
PACIFIC OCEAN

FOR THE MONTH OF
JUNE 1964

DATE OF RUN. . . . . .   JUNE 30, 1964

NUMBER OF OBSERVATIONS	9241
NUMBER OF REJECTIONS	391
SUMMARIZED OBSERVATIONS	8850

PROGRAMMED BY. . .   MARVIN W. CLINE

PROCESSED BY. . . . .   JAMES A. RENNER

TABLE 1.022--SEA SURFACE TEMPERATURES (DEGREES FAHRENHEIT) WITH NUMBER OF OBSERVATIONS
BY ONE-DEGREE QUADRANGLES FOR THE MONTH OF JUNE, 1964.

LATITUDE RANGE 59N- 29S   LONGITUDE RANGE 149W-140W

LATITUDE \ LONGITUDE	149W	148W	147W	146W	145W	144W	143W	142W	141W	140W
59N	(0)	(0)	(0)	50 (2)	(0)	42 (1)	56 (2)	54 (3)	54 (1)	55 (1)
58N	45 (4)	49 (3)	41 (1)	(0)	(0)	(0)	(0)	47 (1)	(0)	49 (2)
57N	47 (5)	51 (3)	51 (3)	48 (2)	49 (3)	50 (1)	(0)	50 (1)	53 (1)	54 (3)
56N	(0)	49 (1)	(0)	(0)	47 (2)	50 (2)	47 (2)	(0)	49 (1)	51 (2)
55N	46 (2)	(0)	47 (2)	(0)	53 (1)	45 (1)	(0)	50 (1)	46 (1)	50 (2)
54N	50 (4)	45 (2)	43 (1)	47 (3)	(0)	50 (2)	49 (2)	49 (3)	49 (1)	51 (2)
53N	47 (1)	44 (1)	48 (1)	46 (2)	46 (1)	46 (1)	46 (3)	53 (1)	(0)	53 (1)
52N	46 (9)	46 (6)	46 (6)	47 (6)	46 (5)	48 (6)	48 (3)	49 (2)	49 (2)	46 (4)
51N	46 (3)	46 (7)	48 (5)	46 (8)	47 (10)	46 (6)	48 (9)	49 (6)	47 (5)	47 (5)
50N	46 (3)	48 (5)	46 (5)	47 (5)	46 (7)	46 (7)	46 (7)	48 (10)	46 (4)	48 (9)
49N	46 (5)	48 (7)	47 (3)	48 (9)	46 (2)	51 (7)	47 (5)	49 (3)	50 (6)	50 (3)
48N	47 (3)	48 (3)	48 (2)	48 (4)	48 (4)	50 (1)	48 (4)	48 (5)	50 (2)	48 (5)
47N	48 (5)	52 (2)	47 (6)	49 (2)	51 (5)	(0)	48 (2)	50 (3)	(0)	50 (3)
46N	52 (2)	50 (8)	52 (3)	(0)	49 (3)	55 (1)	50 (2)	54 (1)	48 (1)	53 (2)
45N	49 (6)	50 (3)	51 (10)	52 (7)	51 (10)	51 (9)	53 (8)	54 (5)	54 (3)	51 (5)
44N	52 (9)	52 (8)	52 (8)	54 (12)	51 (5)	52 (2)	52 (3)	52 (8)	53 (10)	53 (10)
43N	53 (6)	54 (6)	52 (3)	54 (9)	52 (6)	53 (10)	54 (11)	55 (5)	54 (7)	49 (2)
42N	54 (7)	56 (4)	53 (4)	55 (4)	53 (5)	53 (4)	54 (7)	53 (6)	55 (10)	56 (9)
41N	59 (4)	58 (5)	57 (3)	57 (7)	55 (1)	55 (5)	55 (7)	56 (5)	57 (4)	57 (6)
40N	58 (5)	59 (5)	58 (5)	60 (6)	59 (5)	59 (4)	58 (3)	60 (1)	59 (8)	55 (3)
39N	58 (3)	58 (5)	58 (5)	60 (5)	57 (3)	60 (6)	58 (9)	61 (5)	59 (9)	58 (4)
38N	(0)	62 (7)	61 (2)	65 (4)	64 (1)	62 (4)	58 (3)	61 (4)	60 (3)	60 (11)
37N	62 (2)	62 (4)	61 (3)	61 (6)	61 (4)	61 (4)	61 (4)	62 (6)	60 (6)	62 (5)
36N	68 (4)	60 (1)	63 (4)	64 (1)	63 (7)	63 (2)	64 (6)	62 (6)	63 (5)	64 (5)
35N	66 (2)	(0)	64 (3)	65 (2)	66 (2)	63 (6)	63 (5)	64 (5)	65 (3)	64 (8)
34N	70 (5)	65 (5)	66 (4)	66 (1)	65 (12)	61 (2)	66 (4)	66 (5)	64 (2)	65 (5)
33N	65 (1)	67 (2)	65 (4)	68 (5)	66 (1)	62 (3)	65 (1)	64 (3)	(0)	64 (1)
32N	69 (1)	68 (2)	66 (5)	70 (1)	64 (2)	64 (1)	64 (4)	65 (1)	66 (3)	60 (2)
31N	69 (7)	67 (4)	67 (4)	67 (1)	(0)	69 (2)	67 (3)	67 (1)	(0)	66 (16)
30N	70 (2)	73 (1)	68 (2)	70 (1)	66 (1)	(0)	69 (4)	69 (11)	66 (15)	65 (2)

TABLE 2.058--BAROMETRIC PRESSURES (MILLIBARS), X- AND Y-WIND VECTORS (KNOTS), AND AVERAGE WIND SPEED (KNOTS) WITH NUMBER OF OBSERVATIONS BY ONE-DEGREE QUADRANGLES FOR THE MONTH OF JUNE, 1964.

LATITUDE RANGE 59N- 29S LONGITUDE RANGE 149W-140W

LATITUDE	LONGITUDE	149W	148W	147W	146W	145W	144W	143W	142W	141W	140W
47N	BAR	1014.4(5)	1026.5(1)	1011.2(6)	1018.2(2)	1015.0(6)	.0(0)	1005.5(2)	1019.0(3)	.0(0)	1018.1(3)
	X-	3 (5)	0 (1)	5 (6)	17 (2)	-1 (6)	0 (0)	-1 (2)	-2 (3)	0 (0)	0 (3)
	Y-	12 (5)	2 (1)	7 (6)	7 (2)	3 (6)	0 (0)	-10 (2)	5 (3)	0 (0)	6 (3)
	VEL	17 (5)	3 (1)	21 (6)	20 (2)	14 (6)	0 (0)	24 (2)	11 (3)	0 (0)	12 (3)
46N	BAR	1021.5(2)	1016.4(5)	1020.6(3)	.0(0)	1009.0(3)	1013.5(1)	1001.0(2)	1012.0(1)	1016.2(2)	1018.3(2)
	X-	0 (2)	11 (5)	9 (3)	0 (0)	7 (3)	18 (1)	-1 (2)	-2 (1)	11 (2)	9 (2)
	Y-	1 (2)	4 (5)	3 (3)	0 (0)	-1 (3)	15 (1)	0 (2)	1 (1)	-4 (2)	-3 (2)
	VEL	8 (2)	15 (5)	13 (3)	0 (0)	16 (3)	24 (1)	10 (2)	3 (1)	13 (2)	14 (2)
45N	BAR	1015.6(3)	1009.8(2)	1010.6(11)	1017.6(6)	1017.2(10)	1012.0(8)	1016.7(8)	1016.1(4)	1009.0(3)	1007.6(4)
	X-	2 (3)	-13 (2)	4 (11)	7 (6)	11 (10)	5 (8)	10 (8)	8 (4)	2 (3)	1 (4)
	Y-	3 (3)	9 (2)	7 (11)	3 (6)	3 (10)	6 (8)	3 (8)	2 (4)	-1 (3)	3 (4)
	VEL	11 (3)	20 (2)	15 (11)	12 (6)	16 (10)	18 (8)	16 (8)	16 (4)	13 (3)	11 (4)
44N	BAR	1008.6(7)	1013.8(7)	1021.0(8)	1014.6(11)	1020.2(5)	1014.0(3)	1016.5(3)	1020.1(5)	1015.0(9)	1015.5(7)
	X-	0 (7)	7 (7)	3 (8)	6 (11)	7 (5)	-3 (3)	7 (3)	-1 (5)	9 (9)	-4 (7)
	Y-	5 (7)	15 (7)	-1 (8)	6 (11)	2 (5)	-1 (3)	11 (3)	-1 (5)	1 (9)	-8 (7)
	VEL	18 (7)	21 (7)	13 (8)	15 (11)	16 (5)	12 (3)	14 (3)	11 (5)	13 (9)	28 (7)
43N	BAR	1008.8(4)	1012.4(6)	1010.7(3)	1015.3(8)	1015.6(5)	1015.7(11)	1018.9(8)	1017.9(4)	1022.1(6)	1023.5(1)
	X-	-7 (4)	7 (6)	-1 (3)	-1 (8)	-2 (5)	7 (11)	4 (8)	10 (4)	0 (6)	-15 (1)
	Y-	3 (4)	2 (6)	-7 (3)	-3 (8)	-8 (5)	3 (11)	-2 (8)	3 (4)	6 (6)	0 (1)
	VEL	12 (4)	14 (6)	11 (3)	8 (8)	14 (5)	14 (11)	12 (8)	15 (4)	14 (6)	16 (1)
42N	BAR	1014.5(7)	1021.4(4)	1019.3(5)	1021.9(2)	1017.9(3)	1018.3(3)	1004.2(6)	1019.6(5)	1025.6(9)	1016.5(7)
	X-	7 (7)	7 (4)	3 (5)	6 (2)	14 (3)	10 (3)	3 (6)	10 (5)	0 (9)	0 (7)
	Y-	10 (7)	4 (4)	8 (5)	-4 (2)	-2 (3)	0 (3)	1 (6)	2 (5)	-1 (9)	2 (7)
	VEL	17 (7)	12 (4)	12 (5)	10 (2)	19 (3)	12 (3)	10 (6)	15 (5)	14 (9)	15 (7)
41N	BAR	1024.1(4)	1020.1(5)	1020.4(2)	1016.6(4)	1013.5(1)	1014.3(6)	1014.6(5)	1025.9(3)	1018.8(5)	1020.7(6)
	X-	2 (4)	5 (5)	-4 (2)	2 (3)	-11 (1)	6 (6)	0 (5)	9 (3)	3 (5)	2 (6)
	Y-	9 (4)	5 (5)	13 (2)	5 (3)	9 (1)	6 (6)	-6 (5)	-2 (3)	0 (5)	-4 (6)
	VEL	10 (4)	10 (5)	15 (2)	10 (3)	15 (1)	16 (6)	16 (5)	13 (3)	9 (5)	12 (6)
40N	BAR	1015.0(5)	1015.4(3)	1021.0(6)	1022.1(6)	1022.2(4)	1017.8(4)	1025.7(2)	1002.2(1)	1013.9(8)	1016.3(3)
	X-	4 (5)	11 (3)	8 (6)	10 (6)	11 (4)	9 (4)	7 (2)	-5 (1)	9 (8)	0 (3)
	Y-	2 (5)	5 (3)	0 (6)	11 (6)	21 (4)	7 (4)	-10 (2)	15 (1)	9 (8)	3 (3)
	VEL	13 (5)	13 (3)	14 (6)	16 (6)	25 (4)	15 (4)	13 (2)	17 (1)	16 (8)	12 (3)
39N	BAR	1008.4(3)	1006.9(4)	1010.4(5)	1021.6(5)	1011.1(3)	1022.8(6)	1022.4(10)	1021.5(6)	1020.3(8)	1020.6(3)
	X-	6 (3)	10 (4)	5 (5)	5 (5)	0 (3)	3 (6)	4 (10)	4 (6)	6 (8)	8 (3)
	Y-	-3 (3)	8 (4)	4 (5)	6 (5)	10 (3)	3 (6)	2 (10)	9 (6)	3 (8)	-1 (3)
	VEL	15 (3)	14 (4)	16 (5)	10 (5)	10 (3)	11 (6)	14 (10)	14 (6)	14 (8)	14 (3)
38N	BAR	.0(0)	1020.2(7)	1013.0(2)	1022.3(3)	.0(0)	1018.8(5)	1018.9(3)	1019.1(4)	1023.2(4)	1020.4(10)
	X-	0 (0)	8 (7)	4 (2)	1 (3)	0 (0)	7 (5)	2 (3)	1 (4)	2 (4)	5 (10)
	Y-	0 (0)	5 (7)	12 (2)	0 (3)	0 (0)	9 (5)	6 (3)	8 (4)	-6 (4)	2 (10)
	VEL	0 (0)	16 (7)	14 (2)	14 (3)	0 (0)	17 (5)	7 (3)	9 (4)	11 (4)	13 (10)
37N	BAR	1022.5(2)	1023.9(4)	1024.2(3)	1024.0(5)	1019.1(5)	1014.9(3)	1021.3(3)	1021.1(6)	1016.3(6)	1025.6(4)
	X-	6 (2)	4 (4)	5 (3)	3 (5)	2 (5)	4 (3)	9 (3)	4 (6)	7 (6)	3 (4)
	Y-	0 (2)	7 (4)	-5 (3)	3 (5)	-1 (5)	-2 (3)	1 (3)	2 (6)	1 (6)	2 (4)
	VEL	14 (2)	12 (4)	9 (3)	9 (5)	8 (5)	10 (3)	10 (3)	10 (6)	14 (6)	5 (4)
36N	BAR	1027.5(4)	.0(0)	1030.6(3)	1030.1(1)	1024.7(8)	1024.7(3)	1017.1(3)	1021.0(6)	1022.7(5)	1028.2(5)
	X-	2 (4)	0 (0)	4 (3)	2 (1)	5 (8)	5 (3)	7 (3)	7 (6)	9 (5)	4 (5)
	Y-	-2 (4)	0 (0)	6 (3)	1 (1)	-2 (8)	-3 (3)	5 (3)	-2 (6)	0 (5)	-5 (5)
	VEL	7 (4)	0 (0)	11 (3)	3 (1)	10 (8)	12 (3)	13 (3)	12 (6)	13 (5)	9 (5)

TABLE 3.015--SEA SURFACE TEMPERATURES (DEGREES FAHRENHEIT AND CENTIGRADE) AND NUMBER OF OBSERVATIONS BY TWO-DEGREE QUADRANGLES FOR THE MONTH OF JUNE, 1964.

LATITUDE RANGE 58N- 28S LONGITUDE RANGE 148W-140W

LONGITUDE / LATITUDE	148W	146W	144W	142W	140W
58N	46.6 (7) 8.1	46.7 (3) 8.2	41.9 (1) 5.5	53.3 (6) 11.8	51.7 (4) 10.9
56N	48.8 (9) 9.3	49.8 (5) 9.9	48.8 (8) 9.3	47.9 (3) 8.8	52.1 (7) 11.2
54N	47.6 (8) 8.7	46.2 (6) 7.9	49.3 (4) 9.6	49.2 (6) 9.6	49.5 (6) 9.7
52N	45.6 (17) 7.6	46.6 (15) 8.1	47.1 (13) 8.4	48.1 (9) 8.9	47.8 (7) 8.8
50N	46.4 (18) 8.0	46.7 (23) 8.2	46.4 (30) 8.0	47.9 (32) 8.8	47.1 (23) 8.4
48N	47.1 (18) 8.4	47.6 (18) 8.7	49.2 (14) 9.6	48.0 (17) 8.9	49.1 (16) 9.5
46N	50.0 (17) 10.0	48.4 (11) 9.1	50.8 (9) 10.4	49.8 (8) 9.9	50.6 (6) 10.3
44N	50.8 (26) 10.4	52.1 (37) 11.2	51.1 (26) 10.6	52.8 (24) 11.6	52.6 (28) 11.4
42N	54.3 (23) 12.4	53.4 (20) 11.9	52.6 (25) 11.4	53.9 (29) 12.2	54.4 (28) 12.4
40N	58.3 (19) 14.6	58.0 (21) 14.4	57.3 (15) 14.1	56.1 (16) 13.4	57.2 (21) 14.0
38N	59.8 (15) 15.4	60.6 (16) 15.9	59.8 (14) 15.4	59.4 (21) 15.2	59.3 (27) 15.2
36N	63.9 (11) 17.7	61.5 (14) 16.4	62.2 (17) 16.8	62.1 (22) 16.7	62.0 (21) 16.7
34N	67.0 (12) 19.4	65.1 (10) 18.4	64.4 (21) 18.0	64.7 (19) 18.2	64.3 (18) 17.9
32N	67.5 (6) 19.7	66.7 (15) 19.3	63.7 (7) 17.6	64.3 (9) 17.9	63.6 (6) 17.6
30N	69.0 (14) 20.6	67.7 (8) 19.8	68.0 (3) 20.0	68.4 (19) 20.2	66.3 (33) 19.1
28N	72.6 (5) 22.6	71.0 (23) 21.7	70.3 (32) 21.3	70.2 (25) 21.2	69.6 (15) 20.9
26N	73.2 (23) 22.9	73.5 (27) 23.1	72.3 (13) 22.4	72.2 (6) 22.3	69.9 (7) 21.1
24N	73.8 (17) 23.2	74.3 (2) 23.5	74.3 (2) 23.5	73.4 (4) 23.0	72.9 (2) 22.7
22N	74.9 (3) 23.8	75.2 (1) 24.0	72.9 (2) 22.7	72.5 (1) 22.5	74.5 (4) 23.6
20N	75.7 (5) 24.3	75.6 (9) 24.2	75.8 (6) 24.3	76.1 (5) 24.5	74.6 (3) 23.7
18N	76.3 (8) 24.6	75.1 (2) 23.9	.0 (0) .0	.0 (0) .0	.0 (0) .0
16N	77.7 (4) 25.4	75.6 (2) 24.2	75.6 (2) 24.2	75.1 (2) 23.9	76.0 (3) 24.4
14N	76.7 (3) 24.8	78.8 (1) 26.0	78.8 (1) 26.0	78.4 (5) 25.8	77.5 (2) 25.3
12N	78.8 (1) 26.0	.0 (0) .0	80.6 (1) 27.0	80.6 (1) 27.0	81.5 (1) 27.5
10N	80.6 (5) 27.0	82.4 (1) 28.0	.0 (0) .0	.0 (0) .0	80.1 (2) 26.7
8N	82.4 (1) 28.0	.0 (0) .0	81.9 (2) 27.7	.0 (0) .0	.0 (0) .0
6N	84.2 (2) 29.0	.0 (0) .0	82.1 (3) 27.8	81.9 (2) 27.7	80.3 (3) 26.8
4N	.0 (0) .0	80.6 (2) 27.0	.0 (0) .0	.0 (0) .0	81.9 (2) 27.7
2N	82.4 (1) 28.0	80.6 (1) 27.0	.0 (0) .0	80.1 (2) 26.7	.0 (0) .0
0N	.0 (0) .0	.0 (0) .0	78.8 (1) 26.0	79.7 (1) 26.5	81.8 (3) 27.7

U.S. BUREAU OF COMMERCIAL FISHERIES SYNOPTIC WEATHER DATA--PACIFIC OCEAN

TABLE 4.022--SEA SURFACE TEMPERATURES (DEGREES CENTIGRADE), AIR TEMPERATURES (DEGREES CENTIGRADE), DEW POINT TEMPERATURES (DEGREES CENTIGRADE), BAROMETRIC PRESSURES (MILLIBARS), X- AND Y-WIND VECTORS (KNOTS), AVERAGE WIND SPEEDS (KNOTS), CLOUD COVER (TENTHS OF SKY COVERED), AND HEAT BUDGET (CALORIES/CENTIMETER-SQUARED/DAY), WITH NUMBER OF OBSERVATIONS BY FIVE-DEGREE QUADRANGLES FOR THE MONTH OF JUNE, 1964.

LATITUDE RANGE 55N- 25S LONGITUDE RANGE 145W-140W

LATITUDE	LONGITUDE	145W	140W
55N	SEA TEMP	8.9 (34)	10.3 (29)
	AIR TEMP	11.0 (34)	11.5 (29)
	DEW PT	7.2 (29)	7.7 (24)
	BAROM	1011.2 (31)	1013.0 (26)
	X-	-4 (31)	2 (26)
	Y-	-3 (31)	0 (26)
	VEL	15 (31)	8 (26)
	CLOUDS	.82 (20)	.81 (18)
	Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)	234 = 311 + -21 + -61 + -45 + 50	203 = 319 + -21 + -72 + -37 + 15
50N	SEA TEMP	8.0 (106)	8.7 (101)
	AIR TEMP	9.3 (106)	10.1 (101)
	DEW PT	7.4 (94)	7.9 (83)
	BAROM	1011.7 (113)	1010.8 (98)
	X-	1 (113)	2 (98)
	Y-	1 (113)	0 (98)
	VEL	13 (113)	14 (98)
	CLOUDS	.95 (99)	.95 (84)
	Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)	169 = 214 + -13 + -43 + -16 + 26	172 = 214 + -13 + -42 + -18 + 30
45N	SEA TEMP	9.5 (114)	10.2 (86)
	AIR TEMP	10.6 (114)	11.1 (86)
	DEW PT	8.6 (93)	9.1 (72)
	BAROM	1014.2 (110)	1013.0 (87)
	X-	4 (110)	3 (87)
	Y-	3 (110)	2 (87)
	VEL	13 (110)	14 (87)
	CLOUDS	.93 (101)	.91 (79)
	Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)	181 = 249 + -15 + -51 + -24 + 23	184 = 266 + -16 + -57 + -30 + 21
40N	SEA TEMP	12.6 (142)	12.4 (150)
	AIR TEMP	13.7 (142)	13.7 (150)
	DEW PT	11.1 (111)	11.2 (123)
	BAROM	1016.8 (125)	1017.3 (130)
	X-	4 (124)	4 (130)
	Y-	4 (124)	1 (130)
	VEL	14 (124)	14 (130)
	CLOUDS	.86 (109)	.90 (114)
	Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)	206 = 309 + -19 + -66 + -43 + 24	198 = 276 + -17 + -55 + -37 + 30
35N	SEA TEMP	16.5 (80)	16.2 (133)
	AIR TEMP	17.9 (80)	16.8 (133)
	DEW PT	14.4 (67)	13.9 (110)
	BAROM	1020.8 (74)	1021.3 (126)
	X-	4 (74)	5 (126)
	Y-	2 (74)	1 (126)
	VEL	11 (74)	12 (126)
	CLOUDS	.80 (70)	.81 (114)
	Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)	224 = 357 + -21 + -71 + -65 + 24	191 = 349 + -21 + -79 + -70 + 11
30N	SEA TEMP	19.4 (74)	18.9 (91)
	AIR TEMP	20.2 (74)	19.1 (91)
	DEW PT	17.0 (57)	15.6 (65)
	BAROM	1019.3 (75)	1023.5 (74)
	X-	0 (75)	-2 (74)
	Y-	0 (75)	0 (74)
	VEL	12 (75)	14 (74)
	CLOUDS	.66 (71)	.78 (72)
	Q(T) = Q(I) + Q(R) + Q(B) + Q(E) + Q(H)	275 = 468 + -28 + -93 + -87 + 15	140 = 383 + -23 + -89 + -134 + 4

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U.S. DEPARTMENT OF THE INTERIOR
MARCH 3, 1849

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